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Compressed Air Magazine

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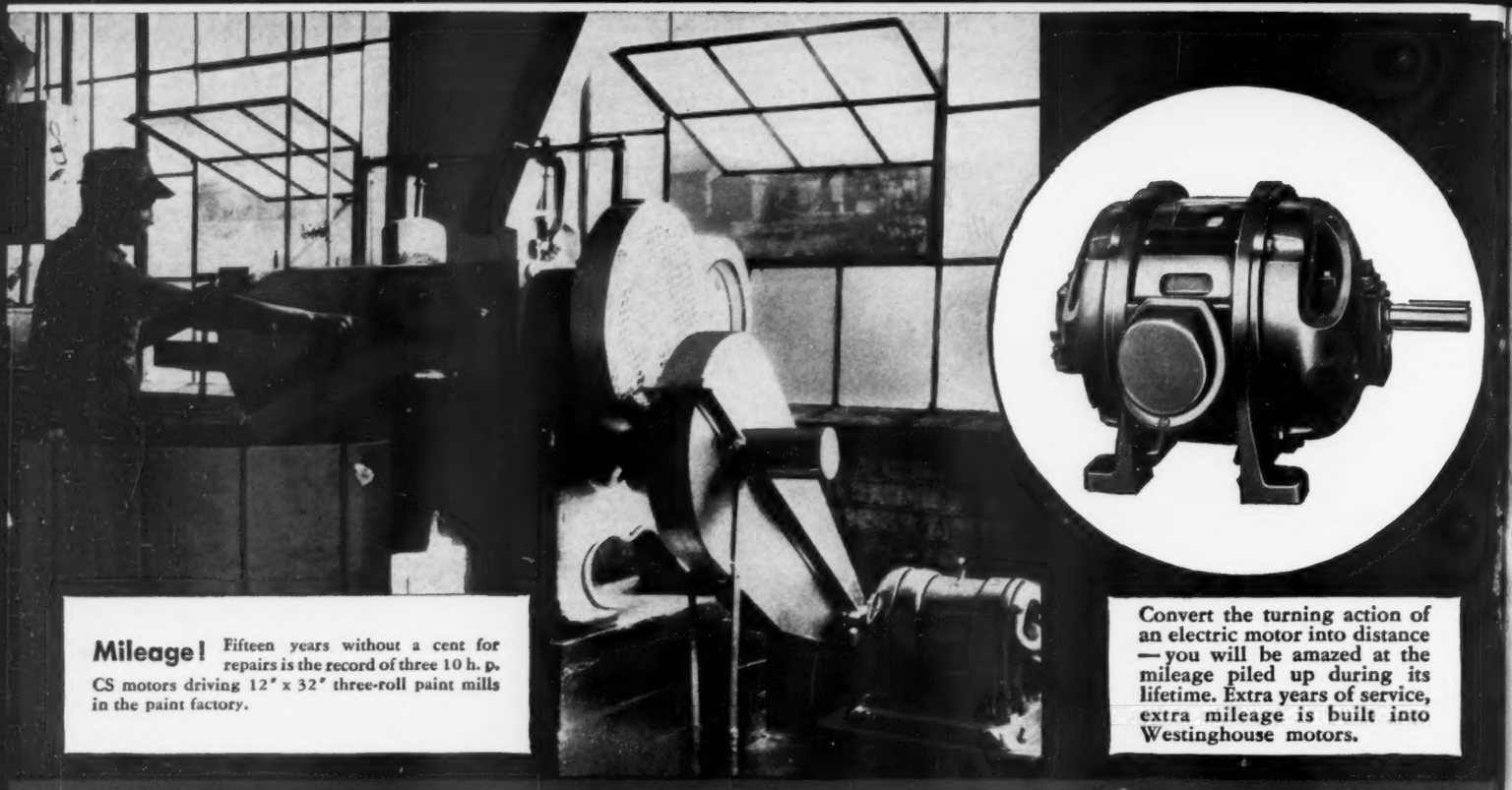
WORLD'S LARGEST DERRICK SCOW TRANSPORTING CONCRETE CYLINDER



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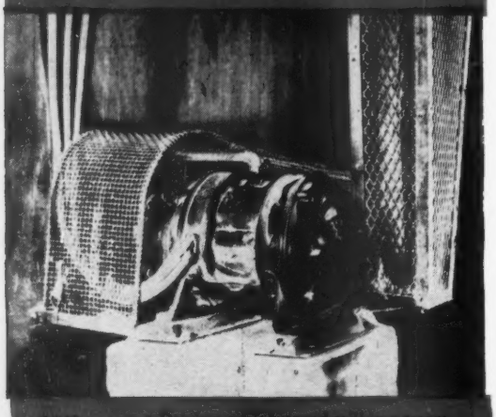

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ON THE COVER

ONE of the world's largest derrick scows is shown handling a 9-foot-diameter reinforced-concrete cylinder used in pier-construction work at Saint John, New Brunswick. Additional information regarding this craft and its work will be found in an article in this issue.

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IN THIS ISSUE

REFRIGERATION as an aid to engineering construction has been employed in relatively few instances, so the work at Gilbertsville Dam, described in succeeding pages, may be termed a new development. Our account of the excavating there of a 90-foot exploratory shaft through water-saturated materials with the assistance of a sheath of ice is, we believe, the first one to appear in the trade press.

•

THE abnormal range of the tides in the Bay of Fundy creates special problems for the builder of berths for deep-draft vessels. Beginning on page 5784, W. M. Goodwin describes two different methods of construction that have been used successfully in Saint John Harbor.

•

FORTY years ago the Klondike teemed with humanity partaking in one of the maddest gold rushes the world has ever known. A few gained riches, the majority reaped only disappointment and disillusionment. Today the Klondike is a tranquil place, with huge dredges systematically winnowing the precious yellow metal from the acres of gravel from which the frenzied horde of the discovery era skimmed the cream. This month R. C. Rowe tells the story of Yukon gold.

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WE REGRETFULLY announce the death, on January 1, of Robert A. Lundell, vice-president of Compressed Air Magazine Publishing Company. Mr. Lundell had been active in the affairs of the magazine for nearly twenty years and had been an official for more than six years. He was 44 years old.

Compressed Air Magazine

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Freezing Aids Shaft Excavating

B. W. Goodenough*
and
Roger F. Rhoades†

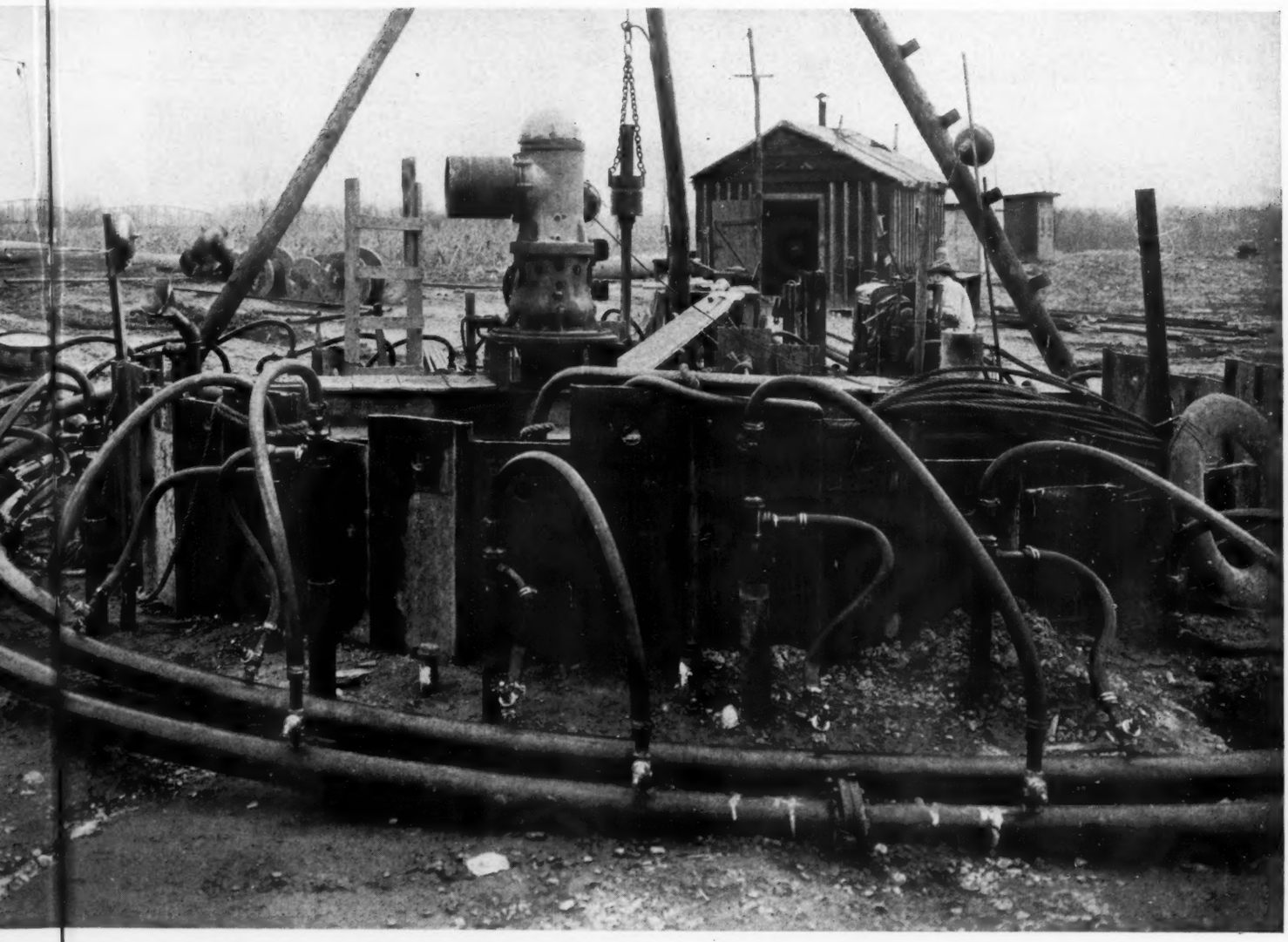
IN EXPLORING the site of Gilbertsville Dam, which is a part of the U. S. Government's great Tennessee Valley Authority project, a shaft was carried down through 90 feet of water-saturated gravels, sands, and clays after an impervious surrounding sheath of frozen material had been formed by means of a refrigerating system of original design. Although the operations were experimental, they nevertheless demonstrated that earth refrigeration as an aid to excavation has many advantages. In the undertaking in question, the danger of sand boils and blows was thereby removed; all work was done under dry conditions; pumping was obviated; and completely informative examination was permitted of many natural conditions that required clarification before designs and estimates could be made.

The use of refrigeration in connection with exploratory and construction work is not entirely without precedent. At Grand Coulee Dam, sliding overburden materials were frozen to immobility to enable placing permanent structures without excessive excavating; localized water flows in mines have occasionally been stopped by freezing;

*Formerly Senior Engineer, Tennessee Valley Authority, now Chief Engineer for Pacific Constructors, Inc., at Shasta Dam.
†Associate Geologist, Tennessee Valley Authority.

INSIDE THE SHAFT

At the upper left is a view up the shaft, showing frozen sediments extending out from the walls to the square-set braces, a distance of about 4 feet. At higher elevations, above the sediments where water had been, a coating of ice approximately 2 feet thick lined the walls. Details of the ring and square-set bracing may be seen at the left edge of the picture. The lower picture illustrates how the sheet piling contacted the bedrock intimately, thereby demonstrating the practicability of driving a cut-off wall through the 90 feet of overburden at the dam site. Crowding of the piles, as a result of driving them in a comparatively small circle, caused deflections which led to the separation of adjacent members in a few cases. The gaps thus formed permitted an influx of water, sand, and gravel until these materials were frozen to a state of immobility by means of an ammonia-brine refrigerating system with a rated capacity of about 50 standard tons.



ARRANGEMENT OF FREEZING PIPES

Around the shaft was arranged a circle of vertical double pipes extending to and penetrating bedrock. Each pipe assembly consisted of a 1-inch size within a 2-inch size. Outside of this ring of pipes and lying on the ground were two circular headers. Calcium-chloride brine piped from the refrigerating plant entered the outer header and was fed from it into the inner pipes, whence it descended to the bottom and flowed out and upward through the annular space between the two pipes. Upon reaching the surface it entered the inner circular header and was returned to the refrigerating plant for recooling and for recirculation. In this way a sheath of ice was formed around the shaft.

and it is said that in Holland earth-freezing methods have been used to assist in excavating.

Engineering literature, at least in the English language, contains only meager mention of instances where refrigeration and engineering operations have been coordinated. Necessarily, application of the method to specific conditions in the field requires a fresh approach, as there is essentially no precedent to serve as a guide. Therefore, it was not unexpected when the Gilbertsville installation was found to have deficiencies in design which, while not great enough to prevent the ultimate success of the undertaking, were responsible for an observable loss in efficiency.

Gilbertsville Dam site crosses the Tennessee River and is about 22 miles upstream from the point where the latter joins the Ohio. A characteristic of the lower sections of these two river valleys is the thick accumulation of fluvial sediments upon which the streams flow (at Gilbertsville these sediments cover the bedrock floor of an ancient buried valley to a depth which varies up to 120 feet). Many of the design and construction problems that required elucidation were the result of the presence of this thick cover of highly pervious and mobile materials.

It was believed that a sheet-piling cut-off wall would be desirable beneath certain parts of the site where the overburden sediments reached a thickness of 90 feet. The initial objective of the test shaft was therefore to observe the behavior of sheet piling as it was being driven to this depth. The plan was to drive the piling to rock in the form of a circular ring and to excavate within the ring so that the entire length of the individual piles—and especially the points where they contacted the rock—could be exposed for detailed study. Manifestly, such a plan would also serve to uncover, for geological examination, a large surface of the buried bedrock floor of the valley.

As the work progressed it became possible to do more than had originally been contemplated: the effect of cement grouting both in the bedrock and in the overburden was noted; the hydraulic characteristics of the flood-plain sediments were studied; the overburden was accurately logged during excavating as a check against logs previously made up from small drill samples, and core-borings were drilled out of the floor of the shaft at very flat angles to supplement information concerning solution cavities in the bedrock that had already been obtained from vertical borings. Perhaps the most important accomplish-

GENERAL VIEW OF OPERATIONS

The refrigerating plant on the knoll at the right supplied cold brine to the pipes penetrating the ground around the shaft at the left. After being circulated underground, the brine was returned to the plant for recooling. All brine pipes were either wrapped, buried, or boxed to provide insulation against radiation losses.

ment, however, was that the experiment demonstrated the feasibility of carrying excavations down through incoherent sediments frozen to a state of immobility.

The test shaft was located on the flood plain and about 600 feet from the river. Fifty sheet piles were assembled around a cylindrical template, each pile interlocked with its neighbors and driven by means of a suspended steam hammer until only a little of it remained above ground. Additional sections were then spliced on to the projecting ends (the total length of the piling being 95 feet), and driving was continued to refusal as the points encountered bedrock. The shaft was 20 feet in diameter.

It was at first planned to excavate the material from within the shaft without recourse to compressed air or to refrigeration, and by continuous pumping to free the shaft of the water which leaked in through the interlocks of the piling, which was to prevent the inflow of prohibitive amounts of sand and water. Excavation by this method proceeded successfully to elevations well below the water table; but with increasing depth recurrent sand boils and blows occurred on the floor of the shaft, coupled with subsidence in the ground surface outside of it, indicating an influx of material through the interlocks, beneath the bottom of the piling, or through openings between piles where interlock failures might have caused adjacent piles to separate.

While it was not known at the time which of these modes of entry was responsible for the inflowing material, it was evident that the increasing differential head developing between the inside and the outside of the shaft was the underlying cause of the blows. The sediments were too fine-grained to permit free drainage which would have relieved this differential pressure, and flow of the sediments, themselves, was induced by the accumulated stress.

To combat this tendency, a procedure was inaugurated by which the shaft was filled with water to destroy the differential head between the inside and the outside of the shaft, excavating then being done under water with a clamshell to a depth of 10 to 20 feet below the completed bracing. Coarse gravel was next placed in the shaft up to the level to which the excavated material had extended. With that done, the shaft was again unwatered. The pad of gravel so formed not only assured free drainage, which partly offset the accumulating pressures, but the gravel was too coarse in size to flow with any high degree of mobility. After that, the gravel was excavated in short stages, as necessary, to permit the installation of additional bracing while pumping proceeded continuously. When only a thin pad of gravel remained, and signs of incipient instability were discovered, the cycle was repeated.

As excavating continued below the 60-foot depth, large breaks in the sheet piling were exposed. These had been caused by the separation of certain interlocks and by the divergence of adjacent piles—a condition that had clearly been responsible for the sand boils and the blows which had hindered the earlier operations. In spite of these openings in the sheet-piling wall of the shaft, excavating was carried down to a depth of about 78 feet, or to within 12 feet of bedrock, by the use of successive pads of gravel, assisted by cement grout injected into the sediments near bedrock.

At this elevation a violent sand blow occurred which raised the level of the floor of the shaft 21 feet, indicating that excavation by the means described had reached its practicable limit. It was therefore decided to immobilize the flowing sediments by refrigeration, and in that way not only to accomplish the purpose of the test-shaft operations but also to test the applicability of freezing processes to projects of this nature.

A refrigerating plant of the traditional ammonia-brine type was installed. Schematically, its operation was as follows: Ammonia was compressed (and thereby heated) in an ammonia compressor. The compressed ammonia gas was forced into a tubular atmospheric condenser where, still under high pressure, it was cooled by water spray and condensed. Leaving the condenser, the ammonia liquid passed through an expansion valve into a low-pressure system. Relieved of the pressure, the ammonia liquid volatilized, at the same time absorbing the heat (heat of vaporization) necessary to bring about this change of state. The pipes conducting the ammonia gas through the low-pressure system were placed inside the pipes through which the brine was being circulated (brine cooler), and the heat required for the vaporization of the ammonia was abstracted from the brine, which was thereby cooled. Emerging from the brine cooler, the ammonia returned to the compressor to initiate a new ammonia cycle. The calcium-chloride brine, cooled in the brine cooler by the vaporizing ammonia, was circulated through the refrigerating system at the test shaft by pumping and, in turn, abstracted heat from the ground. The ground was thus cooled and the brine was warmed. The warmed brine was returned to the brine cooler for recooling and the beginning of a new cycle.

The system at the test shaft through which the cold brine was transmitted into the ground was composed of a series of vertical freezing pipes and of two circular headers which lay on the ground around the perimeter of the shaft. Each freezing pipe

consisted of a 1-inch pipe inside of a 2-inch pipe, the latter being plugged at the bottom and the former being suspended so that its lower open end hung about 6 inches above the plugged bottom of the surrounding 2-inch pipe. These freezing pipes extended from the ground surface to points about 5 feet deep in bedrock.

Cold brine leaving the refrigerating plant flowed into one of the circular headers and was fed through short hose connections to the internal 1-inch pipes of the freezing holes. Descending to the bottom, the brine entered the respective annular spaces between the 1-inch and the 2-inch pipes and ascended to the surface where it entered the other circular header, whence the brine, warmed by the saturated sediments which surrounded the freezing pipes, was delivered to the refrigerating plant for recooling.

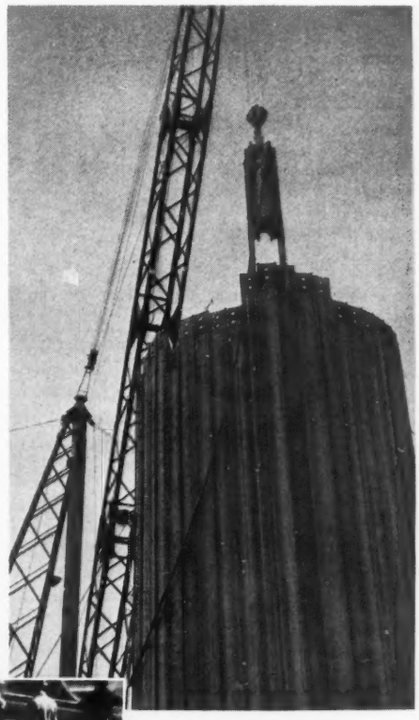
The capacity of a refrigerating plant is commonly expressed in terms of standard tons of refrigeration. Since it requires the transfer of 144 Btu. to melt one pound of ice (or to freeze one pound of water) at a temperature of 32°F., it takes 2,000 times 144 or 288,000 Btu. to melt one ton of ice. The transfer of 288,000 Btu. in 24 hours is therefore called one ton of refrigeration.

The work done on the ammonia as it is acted upon by the compressor can be expressed in terms of British thermal units, and a compressor capable of applying energy equivalent to 288,000 Btu. to the ammonia in 24 hours (operating under certain arbitrary conditions of temperature and pressure) is said to have a capacity of one standard ton of refrigeration. A refrigerating plant built around such a compressor is given the same rating. The plant installed at the Gilbertsville test shaft was rated at about 50 standard tons of refrigeration, although mechanical conditions prevented its continuous operation under "standard" conditions and limited the daily output to 25 or 30 standard tons when the brine was cooled to between 6 and 10°F.

In order to observe the progress of the freezing processes, cased drill holes were placed in three zones: adjacent to the test shaft, 5 feet from the shaft, and 15 feet from the shaft. The temperatures in these holes were periodically read and recorded, and additional temperatures were also regularly noted. The most critical of these for the interpretation of the freezing operations were considered to be: first, temperature of the brine entering the ground; second, temperature of the brine leaving the ground; third, temperature of the water which filled the shaft.

It was found that underground temperatures adjacent to the shaft (also adjacent to the freezing holes) dropped quickly to below freezing, and that the temperatures 5 feet and 15 feet from the shaft decreased markedly but more slowly, as had been expected. After a period of continuous operation an equilibrium was approached, and continued decreases in temperature, while clearly apparent, were slow in developing. At this stage of the work the temperatures adjacent to the shaft averaged 22°F., those 5 feet away averaged 35°, and those 15 feet away averaged 45°. Inasmuch as the ground-water temperature was normally about 60°, it was obvious that a positive cooling action was taking place.

While temperature recordings clearly indicated positive underground refrigeration, they did not reveal whether or not the shaft was surrounded by an impervious sheath of ice. The formation of such a sheath is the consequence of the gradual enlargement of the individual cylinders of frozen material around the respective freezing pipes. In other words, as adjacent frozen cylinders increase in diameter they ultimately coalesce, and not until such coalescence has joined all the cylinders is the seal complete. Actual observations showed that the necessary coalescence was effected first at ground-water level, thence proceeding slowly downward until the seal at bedrock was formed.

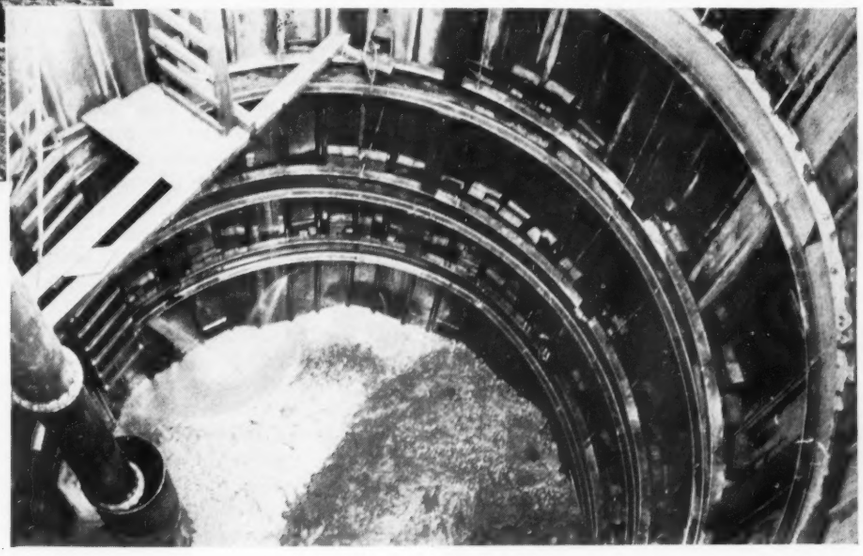


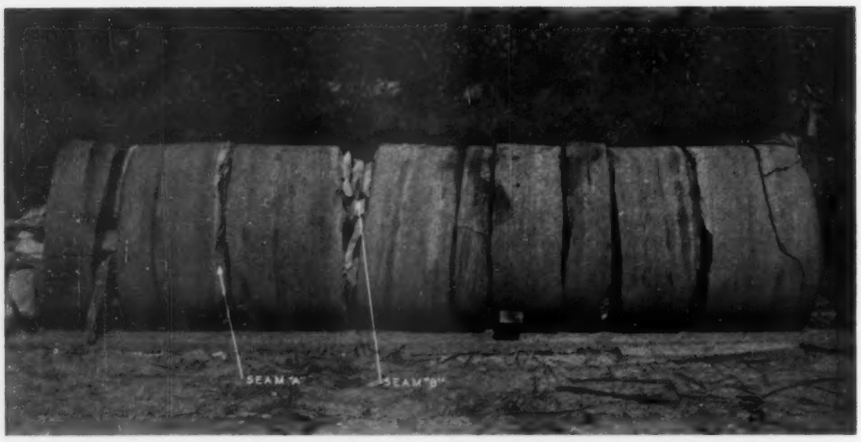
BEFORE FREEZING BEGAN

Excavating was carried to a depth of 78 feet before freezing had to be resorted to to solidify water and mobile sediments. A 14-inch centrifugal pump was used to keep the shaft free of inflowing water. Ring braces, used in conjunction with wooden wedges, supported the shaft walls. Square-set braces were later placed for added reinforcement. During this preliminary period of excavation, sand boils and blows in the shaft were accompanied by subsidences of the ground surface outside (above), indicating that mobile material was entering the shaft through gaps caused by the separation of adjacent piles.

DRIVING THE PILING

Fifty sections of interlocked steel sheet piling, each 45 feet long, were assembled around a wooden template frame and driven into the ground, two at a time, by a suspended steam hammer. After they were in place, additional sections were spliced on to their projecting upper ends to obtain the necessary 90-foot length to reach bedrock.





CORE TAKEN FROM BOTTOM

A 36-inch core was taken from the bedrock floor of the completed shaft to permit examination of the solution cavities in the limestone substrata and to make it possible to observe the manner in which cement grout had entered and filled them. This hole, which extended 12 feet into the bedrock, was drilled with an Ingersoll-Rand Class WS Calyx core drill. The reassembled core is shown here. It has two seams, one perfectly grouted and the other less perfectly but satisfactorily sealed.

Fifty-two freezing pipes were installed about the periphery of the test shaft, giving an average interval between pipes of approximately 27 inches. Therefore, before coalescence could take place, a radial growth of 13½ inches was essential in the case of each cylinder.

Comparison of the water levels inside and outside of the shaft furnished information from day to day concerning the completeness of the seal which was forming about the shaft. Situated as it was close to the river, any change in the level of the latter was reflected by a corresponding change in the level of the ground water in the vicinity of the shaft. As the ground water fluctuated, the water level inside the shaft followed it up or down quickly when no seal existed—when the flow into or out of the shaft was unimpeded—and slowly when the avenues of ingress or escape became restricted. A period of sluggish correspondence between the water level in the shaft and the level of the surrounding water table indicated that the orifices remaining unfrozen were small in size or limited in number. Continued freezing after such a condition had developed finally resulted in a complete and conspicuous independence between the two levels, subsequent fluctuations of the water table having no effect on the water level inside the shaft and proving that an impervious sheath had formed around the shaft. The latter was then considered ready for unwatering. This was done by stages so that the strength and tightness of the frozen sheath could be tested under increasingly greater differential heads.

The large volume of water which filled the shaft was cooled to 32°F. soon after the application of refrigeration, but it was not frozen appreciably at the surface. As water was removed, however, it was found that there was a coating of ice inside the shaft. This had an average thickness of more than 2 feet and concealed the sheet piling and the bracing rings. The sediments which remained at the lower levels of the shaft had frozen to an even greater thickness, forming a lining of about 4 feet on the walls of the shaft—a significant phenomenon attributable to the fact that the sediments, having a limited porosity, contained only a proportionate amount of water which had to be frozen.

Excavation in the center of the shaft offered no difficulties, only the peripheral material being frozen. Removal of the solidified marginal material, however, was a slow and tedious process partly because of the presence of cement grout but mainly because of freezing. The sands, gravels, and clays had attained a degree of hardness and toughness that resisted disintegration even when they were attacked by pavement breakers.

Normally, the frozen material which lined the shaft had no tendency to thaw after removal of the water: air temperatures within the shaft remained consistently in the low twenties and occasionally dropped as low as 16°F., except near the top of the shaft which received the direct rays of the sun. The most important factor in maintaining these low temperatures was that the coldest, heaviest air had a tendency to settle to the bottom and to remain there in the absence of any artificial circulation. Ventilation was undesirable for this reason, although, had safety or comfort necessitated it, precooled air could probably have been circulated without adverse effects. Continuous operation of compressed-air motors (used to actuate diamond drills and accessory pumps in the bottom of the shaft to avoid the generation of noxious fumes by gasoline engines) set up a current of warm air that ultimately raised the temperatures to above freezing. This condition, however, was quickly rectified by suspending activities until the desired low temperatures had again been restored.

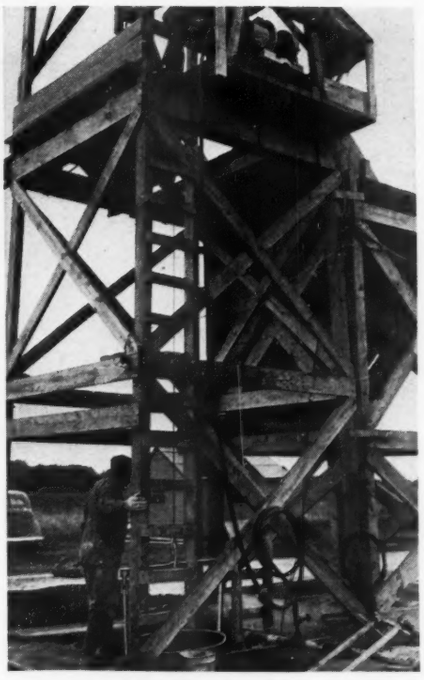
Observations made during and after the unwatering of the shaft proved that a considerable area was affected by the refrigeration, and that an appreciable percentage of the output of the plant was expended in cooling zones remote from the section which had to be frozen. Theoretically, a comparatively thin surrounding wall of frozen sediments is all that is necessary to provide an impervious seal: the expenditure of energy to freeze or cool adjoining zones is manifestly a waste that cannot be avoided because it is impossible to confine the effects of refrigeration to a restricted area. This misapplication of a measurable proportion of the plant output in the case of similar projects will always be an unfortunate but necessary feature of the system. However, simple changes in the arrangement of the freezing pipes have been made, and these will serve drastically to reduce the amount of ineffectual refrigeration in any subsequent installations. The main result of the improvements is that they will greatly lessen the time required for the formation of a seal, thus making for increased economy and flexibility of operations.

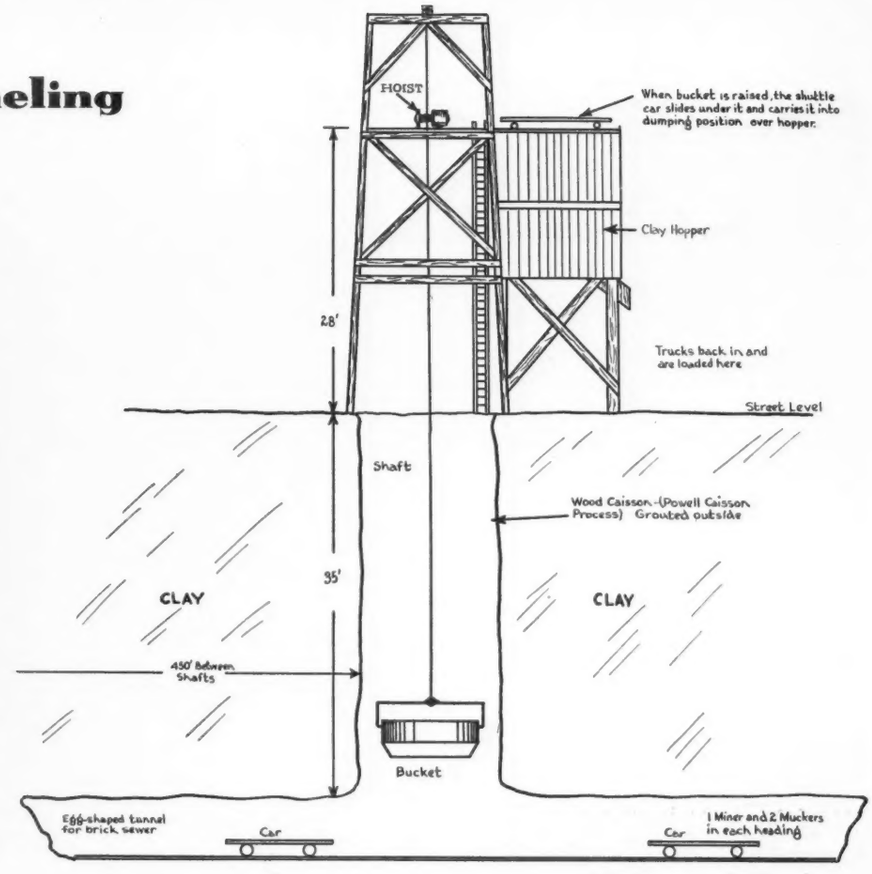
The principal accomplishment of the Gilbertsville refrigeration experiment is that it has demonstrated, on a large scale, the feasibility of combining earth-freezing with excavating in a practical and advantageous manner. Because of the nature of the project, costs—the yardstick of the engineer and constructor—were not the controlling factor. There is no doubt, however, that because of the use of refrigeration, the work of sinking the shaft was completed at far less expense than it would have been had any other established procedure been followed.

The experiment has suggested a number of possible improvements which will, it is believed, increase the efficiency of future installations to the point where they can compete on equal terms, so far as economy is concerned, with conventional methods of excavation in saturated and mobile earth materials. Assuming comparable costs, freezing prior to excavating has many advantages over standard procedures now in common use for the purpose of doing specific things under specific conditions. To advocate the application of refrigeration to all excavation problems regardless of conditions, would, of course, be to exaggerate its adaptability and to ignore its limitations. But, within its own unique sphere of usefulness it promises to become an invaluable tool.

The Gilbertsville test shaft was in the immediate charge of B. W. Goodenough, senior author. The project was under the supervision of E. A. Prokop, acting construction engineer; T. B. Parker, chief construction engineer (now chief engineer); and C. A. Bock, assistant chief engineer (now chief consulting engineer), all of the Tennessee Valley Authority.

Air Hoists Speed Sewer Tunneling





HOISTING SET-UP

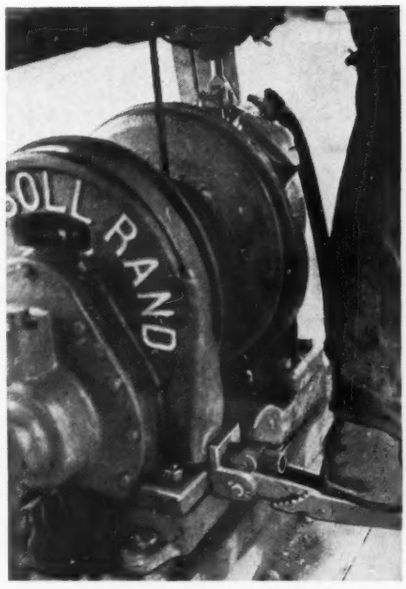
The sketch shows the general scheme of tunneling and hoisting the spoil. During an average 8-hour shift each heading crew dug out and loaded approximately 35 buckets of clay and advanced the tunnel 25 feet. At the left is shown one of the headframes, with the hoist mounted on top and the bucket at the ground level. A close view of one of the size HU air-operated Utility hoists is at the right. The operator has his right hand on the throttle and his right foot on the brake, leaving his left hand free to pull the tipping lever for dumping the bucket.

THE accompanying illustrations show a labor-aiding method of hoisting spoil from an underground excavation that was recently used successfully in the construction of the Parkway Interceptor Sewer in Wayne County, Michigan. The sewer was driven as a tunnel approximately 35 feet under the surface, the crews advancing both ways from the bottoms of shafts spaced 450 feet apart.

The subsoil is predominantly clay, and was excavated with air-operated clay diggers. One miner and two muckers worked at each heading. Spoil was hand loaded into a shallow, cylindrical metal bucket resting on a flat car which was pushed to and from the shaft bottom. When fully loaded, each bucket held from 16 to 18 cubic feet of clay and weighed from 1,960 to 2,180 pounds, of which 200 pounds represented the weight of the bucket. Naturally, the speed of the entire operation depended to a large extent upon the quickness with which a full bucket could be hoisted, its contents dumped, and the empty receptacle lowered again for the purpose of reloading.

As air power was employed underground, economy of plant made it advisable to use it also for hoisting. To provide for gravity loading of trucks on the surface, there was erected over each shaft a timber headframe and an adjoining bin or hopper with a discharge chute under which trucks could be backed. Approximately 28 feet above the ground an Ingersoll-Rand Size HU Utility hoist was mounted on each headframe, the cable from it being passed over a sheave at the top of the structure and thence down the shaft.

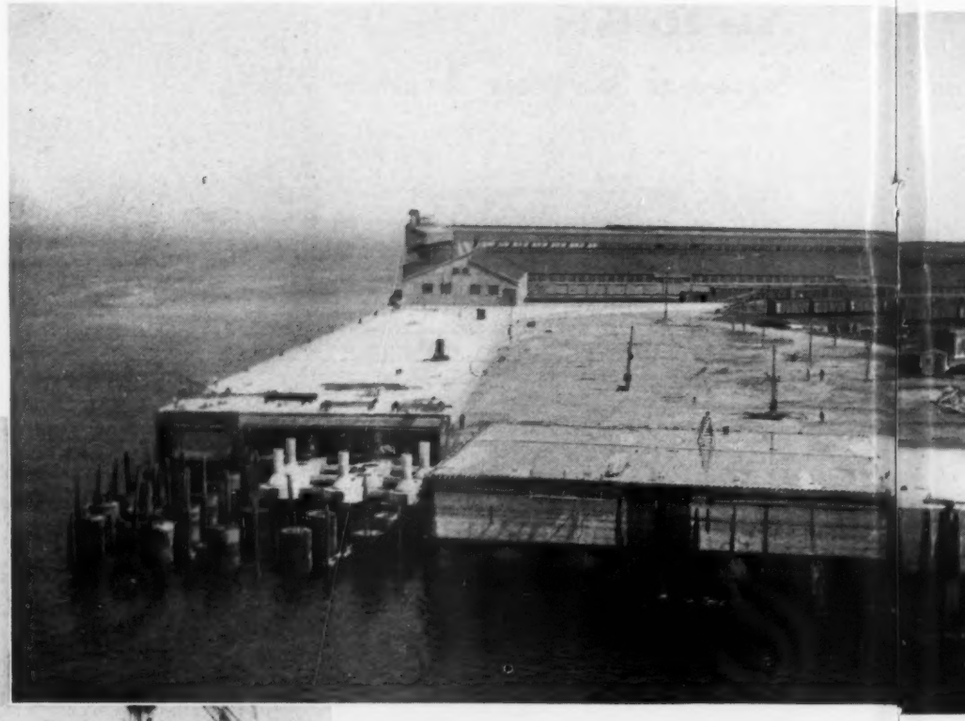
In order to expedite the hoisting cycle, each hoist was equipped with a foot brake. The empty bucket was dropped with the hoist clutch disengaged and stopped with the brake when within a foot or two of the shaft bottom. The clutch was then engaged and the bucket lowered under control on to the car. By providing a foot brake, and by placing the hoist at the top of the headframe, one man was able both to operate the hoist and to dump the bucket, thereby dispensing with a second man who would otherwise have been required. The use of the brake in lowering the bucket also made it possible to save compressed air.

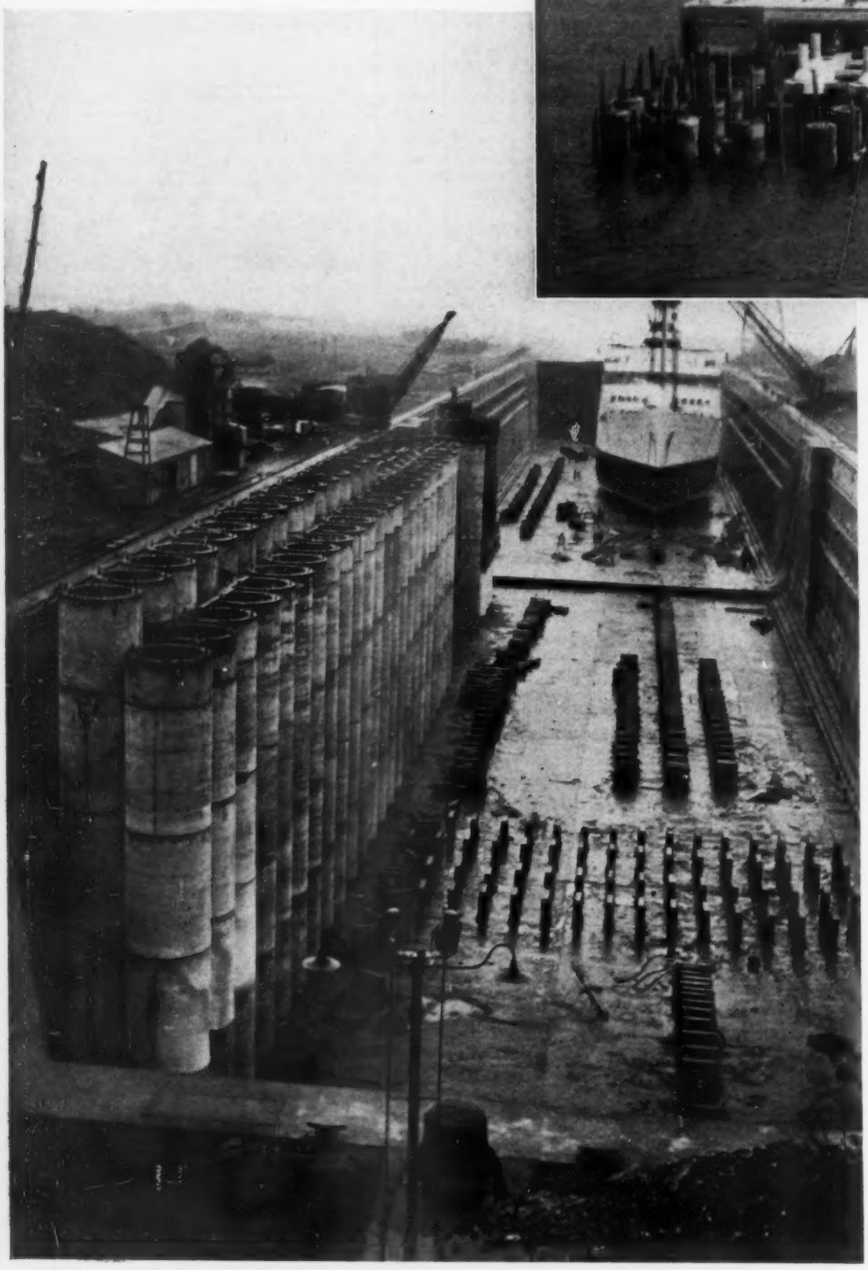


Upon being hoisted to the top of the headframe, the bucket was stopped and a shuttle car was run underneath it. It was then pushed over a few feet on top of the truck-loading bin and dumped into the latter. The average time taken to hoist and dump a loaded bucket and to return the empty to the shaft bottom was 80 seconds. The interval between hoisting operations was approximately four minutes.

New Piers for St. John Harbor

W. M. Goodwin



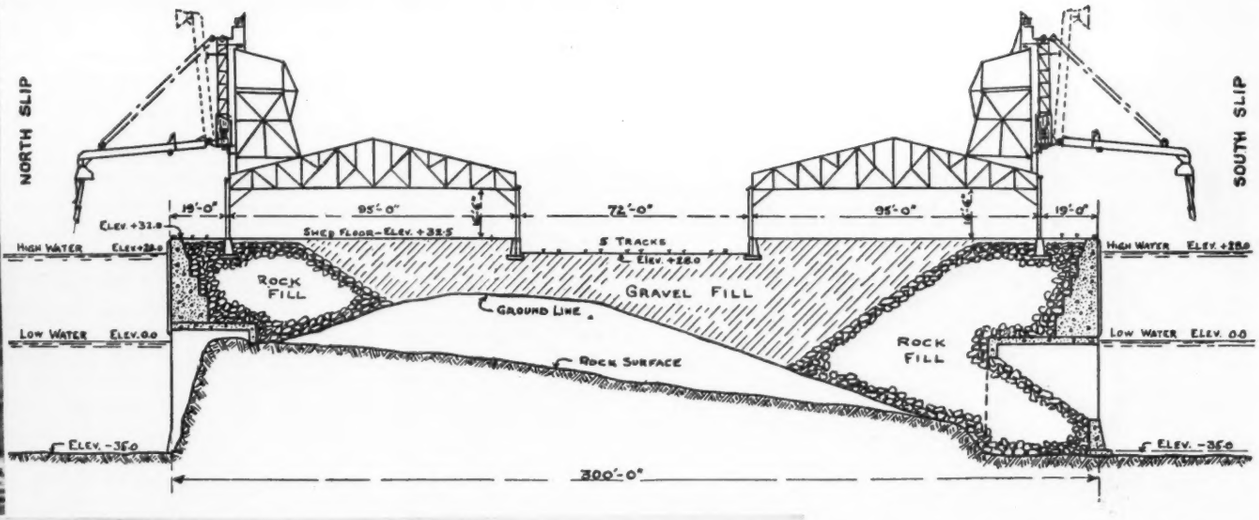


BUILDING AND TRANSPORTING CYLINDERS

The 9-foot-diameter cylinders, of which 208 were incorporated in the pier substructures, were cast in one section of the huge dry-dock at Courtenay Bay, 2 miles from the piers. They were transported, one at a time, to the pier sites by the derrick scow "Foundation Scarboro," which is illustrated on the front cover. As cast, the cylinders were from 55 to 70 feet long.

SAINT JOHN, New Brunswick, has long been an important harbor on the Atlantic coast and now ranks among the four leading seaports of Canada. A century ago it was one of the principal shipbuilding centers on the coast, and its hinterland, readily accessible by the navigable St. John and Kennebekasis rivers, furnished a convenient supply of timber for the maiden voyages of this numerous fleet. Today the vessels that call are mainly transatlantic liners and big freighters with outgoing and incoming cargoes that serve a wide area of eastern Canada. Saint John lies 84 miles nearer Liverpool than Portland, Me., and with excellent low-gradient railroad connections to Quebec and Winnipeg is in a position to carry on export trade with profit.

Saint John Harbor is unique in its tidal range, which is 28 feet. Farther up the Bay of Fundy there is a still greater ebb and flow but no port of any importance. In the old days they took advantage of this marked rise and fall, as the ships were docked at high tide and rested securely and conveniently on the soft mud bottom after the water had receded. Now, however, the vessels must be afloat at all times, so that present-day waterfront construction at Saint John involves some rather unusual problems. The great tidal range, combined with the severe winter climate and the nature of the bottom at West Saint John where the modern piers are located, gave the engineers of the National Harbours Board, who hold and operate the important dockage in the principal seaports of the Dominion in behalf of the public, the toughest job they have so far encountered. But sufficient time has elapsed in the meanwhile to prove that all these difficulties



SECTION THROUGH NAVY ISLAND PIERS

This type of arch construction is economical in the use of concrete and has stood up well during the five years it has been in service despite the fact that the concrete is alternately submerged and exposed to freezing temperatures in winter. Because of the great amount of rock excavation that was required for the building of these piers and their adjoining docks, the site was inclosed within a cofferdam so that the work could be carried on in the dry.

DETAILS OF SUBSTRUCTURE

At the left (above) are two rows of 9-foot-diameter concrete cylinders, partly precast and then built up to the desired height after they had been sunk at their respective locations. Those in the foreground have been filled with concrete. In the middle distance is falsework for the sinking of additional cylinders. At the right are two rows of pile clusters, each group numbering thirteen piles, which are capped with concrete. The completed understructure has a width of 100 feet, and transit sheds and grain galleries were erected on top of it. At the extreme right is the back wall at the edge of the timber relieving platform. The picture at the upper-left shows how the substructure and deck were joined. The two rows of concrete cylinders, bottom-left, rest on bedrock approximately 63 feet below mean high water. The concrete columns (white) which form the two inside rows of supports are built up on pile clusters. Longitudinal and transverse walls on the tops of the cylinders support the outer part of the deck, while adjoining sections rest directly on top of the concrete columns. Columns and cylinders are tied together by 2x2-foot struts.

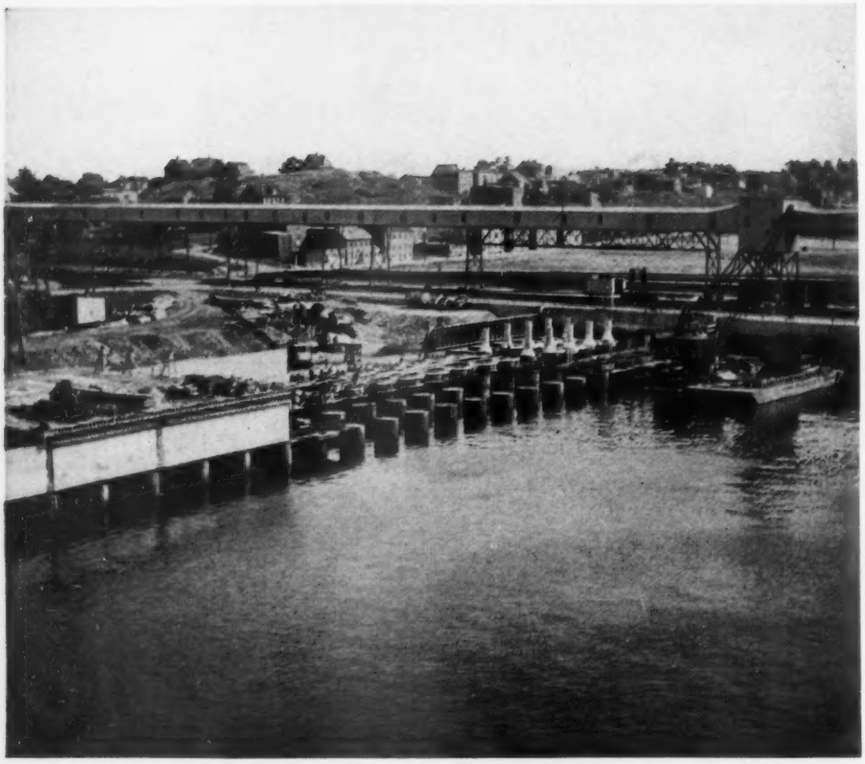
have been skillfully and successfully met.

The complete reconstruction of the piers along the 4,000 feet of harbor frontage at West Saint John was made necessary by reason of the disastrous fire, in June of 1931, that destroyed all the wharves, which were entirely of timber. The piers and sheds around No. 1 Slip and Piers 5, 6, and 7 were rebuilt immediately. They consisted of a concrete superstructure on timber cribs and were ready in December of that year for the important winter traffic. The new Navy Island project was then taken in hand and was of concrete construction throughout. Subsequently, Piers 1, 2, 3, and 4 were rebuilt, also in permanent form.

This article deals chiefly with the last-mentioned operations, but would not be complete without a brief mention of the distinct type of construction employed at Navy Island. The Navy Island site was underlain by bedrock that was at varying elevations from +5 to −30 (mean low water level is datum). The specifications called for docks with a depth of water of 35 feet at low tide, thus necessitating a large amount of rock excavation. A cofferdam was built around the site and the whole job done in the dry. The arched form of construction used, which is illustrated in an accompanying drawing, has proved to be both economical in concrete and sound in design. Its durability depends essentially upon the capacity of the concrete to withstand alternate submersion and exposure to frost during the winter, often in subzero weather. As the Navy Island structures have shown a marked resistance to these severe conditions, the same kind of concrete, with some refinements, has been used in the piers that were subsequently built. The Atlas Construction Company was awarded the Navy Island contract. It was completed in 1933. The Foundation Company of Canada constructed the four newest piers.

Piers 1, 2, 3, and 4 are along a section of the harbor front where bedrock is from 35 to 85 feet below mean low-water level, so no rock excavation was required. It was decided that two rows of concrete columns resting on bedrock backed by two rows of concrete posts on pile clusters would be the best means of obtaining the needful stability with economy. The principal features of both the substructure and the deck are shown in accompanying illustrations.

Accordingly, the substructure of that part of each 100-foot-wide pier upon which the transit sheds and grain galleries rest



PLACING THE DECK

This picture shows Pier No.4 as it was nearing completion. At the left, the wall that supports the outer part of the deck has been erected on top of the concrete cylinders that reach bedrock. Beyond it, in the far corner, some of the 3½-foot-diameter concrete columns that surmount the pile clusters, numbering thirteen each, are ready to receive the 15-inch deck covering.

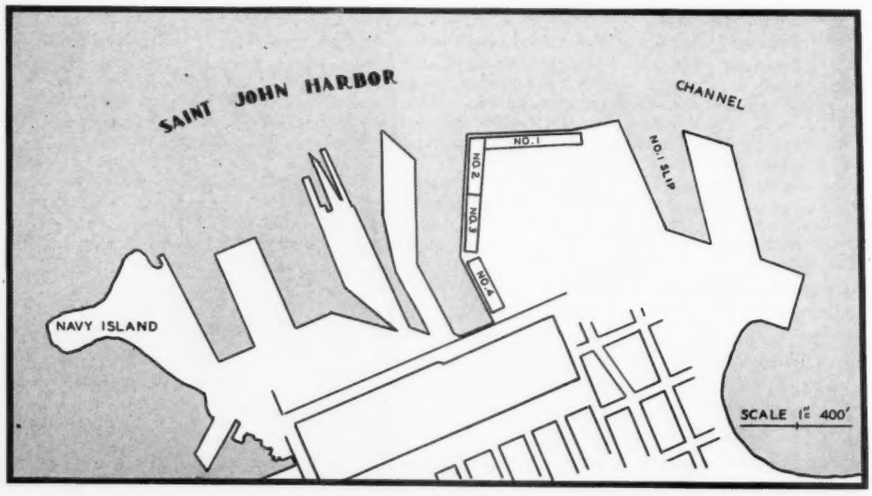
consists of two rows of concrete cylinders behind which are two rows of pile clusters. The tops of these are within the 28-foot range between low and high tides. The outer line of cylinders supports the front wall at right angles to which, and connecting each cylinder in the front row with the one immediately back of it in the second row, is a series of walls each 24 feet long. Upon each cluster of thirteen piles, which are capped with reinforced concrete, is a concrete column, 3½ feet in diameter. These columns are tied to the 15-inch deck and to the tops of the cylinders and pile clusters by 2x2-foot longitudinal and transverse struts. Junction of this concrete structure and the silt behind it is effected by means of a timber relieving platform supported on battered piles, as shown in an accompanying drawing. A rock-and-gravel fill at the toe of the slope and riprap on the surface protects the silt beneath the concrete structure from erosion.

The big dry-dock at Courtenay Bay, 2 miles east of the docks, provided a convenient place for casting the concrete cylinders. This dry-dock is 1,150 feet long, 144 feet wide, and 42 feet deep, and is one of the largest on the continent. It is divided into two sections by gates. The inner chamber was used for casting the cylinders, leaving the outer one free for regular service. An electrically driven screening and mixing plant and a locomotive crane, which transferred the concrete to the cylinders and poured it from a 1-cubic-yard bottom-dump bucket, provided the utmost in efficiency.

The cylinders each have an outside diameter of 9 feet and a heavily reinforced wall 12 inches thick. As cast, they were from 55 to 70 feet long, depending on the depth to bedrock at the points where they were to be placed. They were designed to extend just above low-water level. In the bottom of each was set a steel cutting edge. Steel forms were used both inside and out in making the cylinders. As it has been demonstrated that vibrated concrete withstands severe weather conditions better than concrete not so compacted, the material was carefully treated in layers a foot deep with vibrators of the spade type. It was found that by vibrating the mass from ten to fifteen seconds at a number of points around a cylinder it was possible to get maximum density without causing floating of the mortar. This treatment, combined with painstaking grading and proportioning of the aggregate, is the secret of the excellent concrete placed in the Saint John piers.

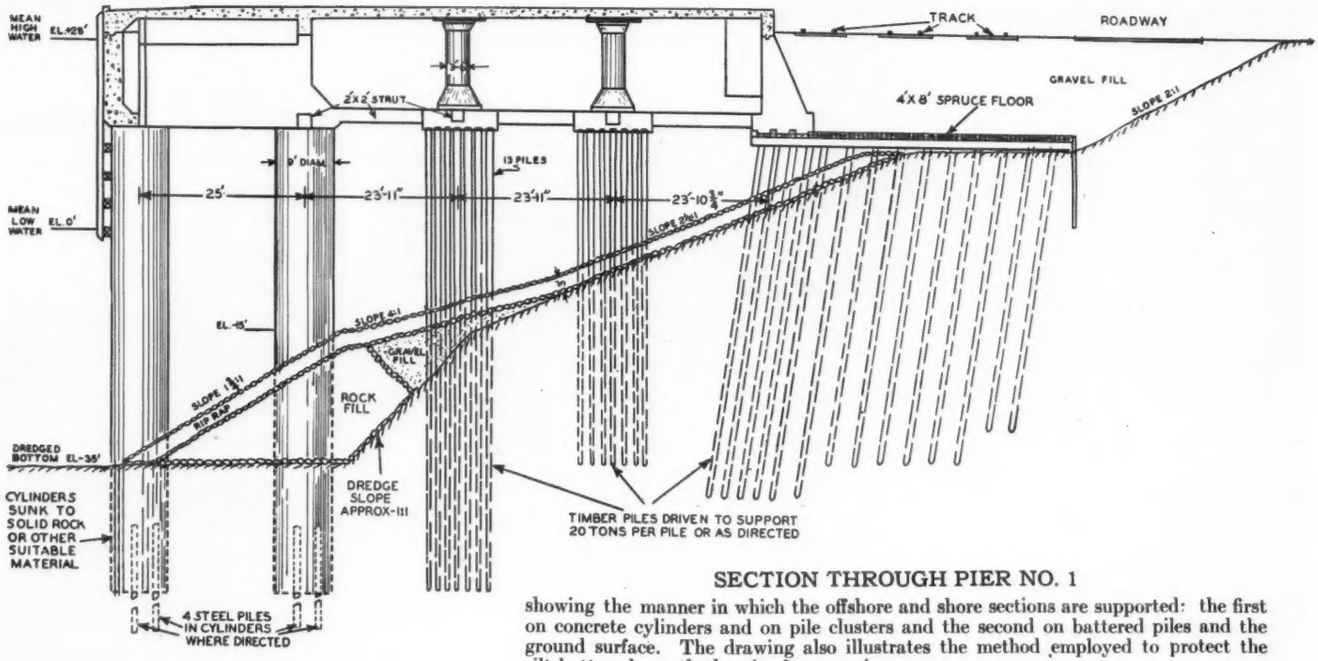
At this point it would be well to look more closely at the quality of the concrete. Two local beaches provided sand and gravel of the various degrees of fineness required. The sand is unusually clean on account of the strong scouring action of the prevailing tides which is much like that of the English Channel. Gravel and fine sand were sized separately by screening and then mixed to give a fineness modulus of 7.55 for the gravel (2 inches to ¼ inch) and 2.88 for the sand (¼ inch to No.100 screen). The extensive experience of the Harbours Board engineers enabled them to proportion these coarse and fine aggregates to the best advantage.

Experiments during the early stages of the work established the fact that 1½ inches slump, together with vibration, gave the densest and best concrete. The cylinders were kept moist inside and out during the curing period of seven days' duration, and were in condition to be moved to a fitting-out berth outside of the dock



SAINT JOHN HARBOR

A fire in 1931 destroyed all structures along a 4,000-foot stretch of waterfront on the side of the harbor shown in the drawing. This article deals with the reconstruction of the Navy Island area and Piers 1, 2, 3, and 4. All the latter were completed in time for the 1938-39 shipping season. The harbor is well protected and free from ice the year round.



SECTION THROUGH PIER NO. 1

showing the manner in which the offshore and shore sections are supported: the first on concrete cylinders and on pile clusters and the second on battered piles and the ground surface. The drawing also illustrates the method employed to protect the silt bottom beneath the pier from erosion.

within twenty days after they had been cast.

Concrete of two qualities was specified: No.1, containing 658 pounds of cement per cubic yard; and No. 2, which contained 470 pounds. The latter was used only for filling the cylinders after placing, while No.1 was used for all the other work because it was exposed to the weather. Tests made weekly for eighteen months showed the average strength to be 4,100 pounds per square inch in seven days and 4,738 pounds in 28 days. The highest 7-day strength was 4,945 pounds, and the highest 28-day strength was 5,655 pounds.

This will be a convenient place to describe the unusual piece of floating equipment—unique in Canada and possibly in the world—that was employed for handling the big cylinders. The *Foundation Scarboro*, designed by the engineering staff of The Foundation Company of Canada for just such purposes as this, is a combined power plant and derrick scow with a hull 100 feet long, 42 feet wide, and 11½ feet in molded depth. Below deck are air compressors with an aggregate capacity of 2,000 cfm., pumps of 1,500 gpm. capacity, and twin diesel-electric units of 400 hp. for operating these and other machines.

The compressor room is particularly worthy of note. The three motor-driven Canadian Ingersoll-Rand units have separate aftercoolers and air receivers. They can provide high-pressure air for rock drills or low-pressure air for caisson work or for certain marine salvage operations, as may be required. Besides these, there is a small machine to furnish air for divers. As it is absolutely necessary to have pure air for underwater workers, special precautions have been taken to avoid fouling it with engine fumes or other gases. The compressor room is virtually a closed steel box, drawing its ventilating air by fan from above deck and the air for the compressors through screened intakes, a separate one for each unit.

The shear legs originally fitted to the *Foundation Scarboro* were designed to lift and to place the 250-ton sections of an 8-foot water intake in Lake Ontario at Toronto. These legs gave a lift of 32½ feet above the deck, which was not enough for the Saint John job. So new shears were made that permit an 85-foot lift of 150 tons and overhang the stern 40 feet. To provide this long reach, however, it was necessary to lash a steel tank on each side of the hull at the stern to provide extra buoyancy.

When several cylinders were cast and ready for transportation, the dry-dock was flooded and the units transferred, one at a time, by the *Foundation Scarboro* to the fitting-out berth just outside. From there each was taken, as needed, across the harbor to the new piers, the *Foundation Scarboro* holding the cylinder vertically while being towed. A timber falsework was used to guide the cylinder into place. Usually, its own weight sufficed to carry it down through the silt, settling proceeding gradually as the material was removed from within with a clamshell. In some cases the weight was sufficient to cause it to settle also through the underlying clay and gravel as excavation inside progressed; but, as a rule, those materials had to be loosened under the cutting edge with a water jet directed by a diver and the cylinder had to be weighted on top with cast iron in amounts up to 50 tons.

Bowlders too large to be handled by the clamshell were drilled and blasted. When a cylinder showed a tendency to deviate from its course, this was corrected by excavating with the water jet under one side of the cutting edge. Thus all the cylinders, 208 in number, were taken to bedrock without much difficulty.

When a cylinder had reached bedrock, the rock was cleaned off by a diver using a jet, and then No.1 concrete was carefully poured into the cylinder to a point above the cutting edge. The remainder was filled with No.2 concrete, using a covered bottom-pour bucket which was lowered through the water. Concrete mixing for this and some other parts of the work was done on the special scow *Foundation Fafnir*.

To extend the cylinders to their final elevation of +15, midway between low and high water, steel forms were placed and filled with No.1 concrete, which was compacted with vibrators. Similarly, forms for the superimposed walls were erected and filled at low water, as were those for the reinforced caps of the pile clusters, the columns surmounting them, the tie beams, and the back wall along the edge of the timber relieving platform.

This extensive section of the Saint John harbor facilities, providing 2,123 feet of berths with a 30-foot draft, was built at a cost of $2,750,000. The demolition of the old timber structures embedded in the silt (a slow job) was started in 1934, and the work of reconstruction was completed in the autumn of 1937. Transit sheds for Pier 1 were finished in time for the 1937-38 season, and the remaining berths are ready for traffic this winter. Thus the Port of Saint John is in an admirable position to handle a large share of the rapidly expanding overseas trade of the Dominion. For the twelve months ending March, 1935, Canada's external trade had a total value, in round figures, of $1,182,350,000 of which $659,900,000 represented exports and $522,450,000 imports.

Gold Mining in Yu

Ewing Galloway Photos

DAWSON

The vortex of Klondike trade and entertainment during the gold rush. Dawson experienced the typical mushroom growth of leading mining camps, and within two years its population was 20,000. The bottom-center picture shows it as it appeared in 1901, when the census gave it 9,142 residents. Above is a view of the main street as it looks today. On the opposite page are seen some of the log buildings that were built during the boom days. Dawson is about 1,500 miles from the mouth of the Yukon River. Its elevation is 1,400 feet. The temperature ranges from 90°F. in summer to −50° in winter.

III

BEFORE discontinuing the subject of placer-gold mining in the Cordilleran area of Canada, it is essential that we consider the Yukon where the famous Klondike gold field was discovered, resulting in one of the greatest gold rushes of all time.

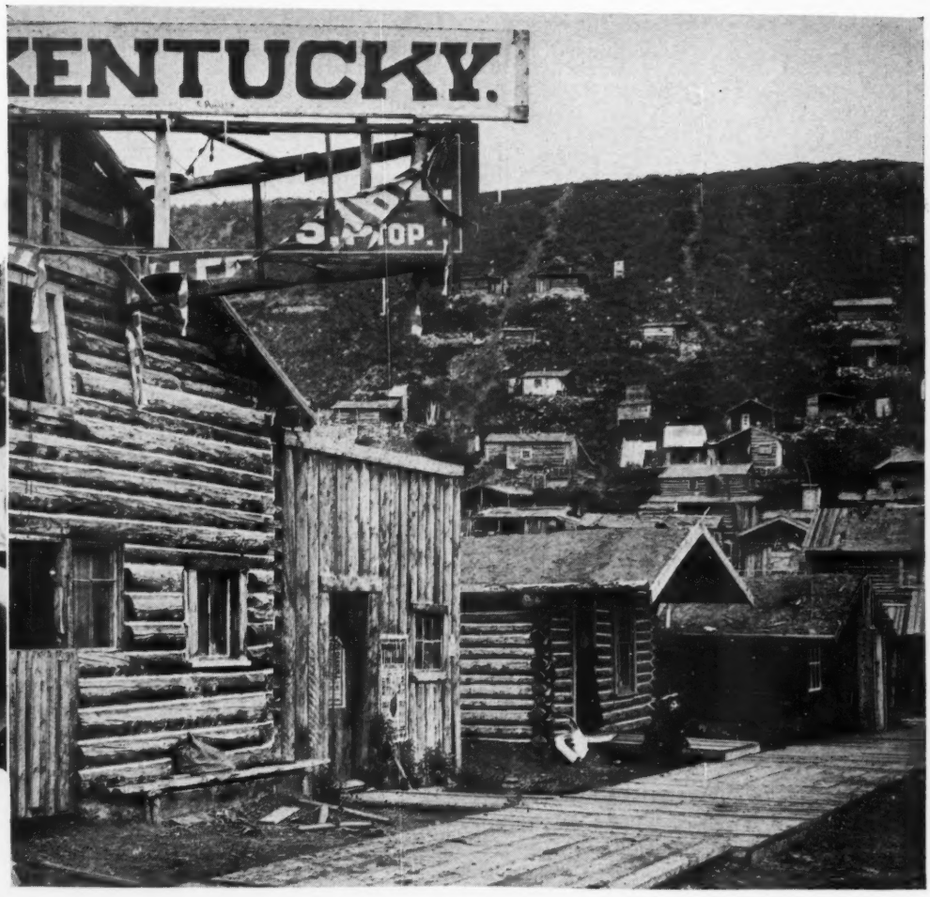
Lying directly north of British Columbia, the Yukon is bounded on the west by Alaska, and, together with the Northwest Territories, is administered by the Government of the Dominion of Canada. Its union with the Province of British Columbia is contemplated, however, and it is more than probable that the territory will lose its picturesque identity.

The northern part of the coastal regions of the North American Continent embracing what are now Alaska and the Yukon was the object of negotiations between Russia and Great Britain during the years 1823-1825. Alaska then belonged to Russia; and a boundary between it and the Yukon was established in a delightfully vague fashion by the courtly diplomats of that time who had not even the remotest idea what manner of country they were negotiating about. The boundary was so vague that it could have been interpreted in almost any fashion; and the fact that the two governments never had any argument regarding it was probably because they were quite friendly and, furthermore, not particularly interested. It has been remarked that it was a pity that some occasion did not arise necessitating a more definite establishment of the dividing line, for then, when Alaska was finally sold to the United States, the long-drawn-out dispute over the matter between that country and Great Britain would have been avoided.

Like neighboring Alaska, the Yukon is a somewhat forbidding land of craggy mountains and immense distances; but both regions share a great blessing—the mighty Yukon River which, in addition to its size, has certain unique features that give it definite distinction. In the first place, the Yukon rises within 15 miles of the sea.

n Yukon Territory

R. C. Rowe



MINERS OF THE NORTHLAND

The picturesque figures (top-center) are typical of the men who work in the Yukon and in other northern mining regions. Some choose to prospect or to do small-scale placer or lode mining by themselves: others, who prefer a regular pay check to being on their own, are employed by the larger and established producing concerns.

Standing at the summit of Dyea Pass one can see running northward the tiny streams that are the source of the Yukon, and one can also see other tiny streams running southward, plunging toward the Pacific Ocean. Fifteen miles to the north of Dyea Pass is Bennett Lake, which is the beginning (or the end) of navigation on the Yukon. From that point the river flows northwesterly for nearly 1,000 miles, just crossing the Arctic Circle, after which it continues through the middle of Alaska for more than 1,200 miles until it flows into the Bering Sea and thence into the ocean which is so close to it source.

From Bennett Lake to Bering Sea is approximately 2,500 miles by the Yukon, which is navigable throughout its course except for about 3½ miles in the canyon lying some 95 miles below that lake. When it is remembered that the river runs through extremely mountainous country, the importance of this great stream is obvious. It provided the facilities for exploring regions which, in the early days, exercised an irresistible pull upon adventurous souls.

Naturally, Alaska and Yukon were for years chiefly noted for furs; but gold was apparently known to be there long before it was actively worked. The late William Ogilvy, who spent many years in the Yukon as an official of the Dominion Government, tells of a missionary who, before the middle of the nineteenth century, traveled up the river to the tributary which afterwards became known as Fortymile River. In his traverse thence to the head of the Tanana, he had to cross Birch Creek, where he found gold. But the worthy divine was more concerned with the souls of men than with the significance of his discovery, for he made no effort to follow it through. He did, however, mention the matter; and the presence of gold was common talk at the trading post of the Hudson's Bay Company at Fort Yukon. The fur traders, on their part, were more interested in pelts than in gold, which they apparently held in low esteem, for they also made no move to test the value of the discovery.

Proof of the casual attitude of the fur traders towards gold is contained in a letter written by a young man in the employ of the Hudson's Bay Company at Fort Yukon to his parents in Toronto in 1864. This letter is quoted by Ogilvy in his book *Early Days on the Yukon*, and is worth noting in view of what later trans-

GENERAL LOCATION MAP

pired. "There is a small river not far from here," he wrote, "that the minister saw so much gold on that he could have gathered it with a spoon. I have often wished to go, but can never find the time. Should I find gold in paying quantities I may turn gold-digger, but this is merely a last resort when I can do no better." There in a nutshell is the opinion of the fur trader of that day regarding that precious metal. A creek where gold could be gathered with a spoon—and it was "a last resort"!

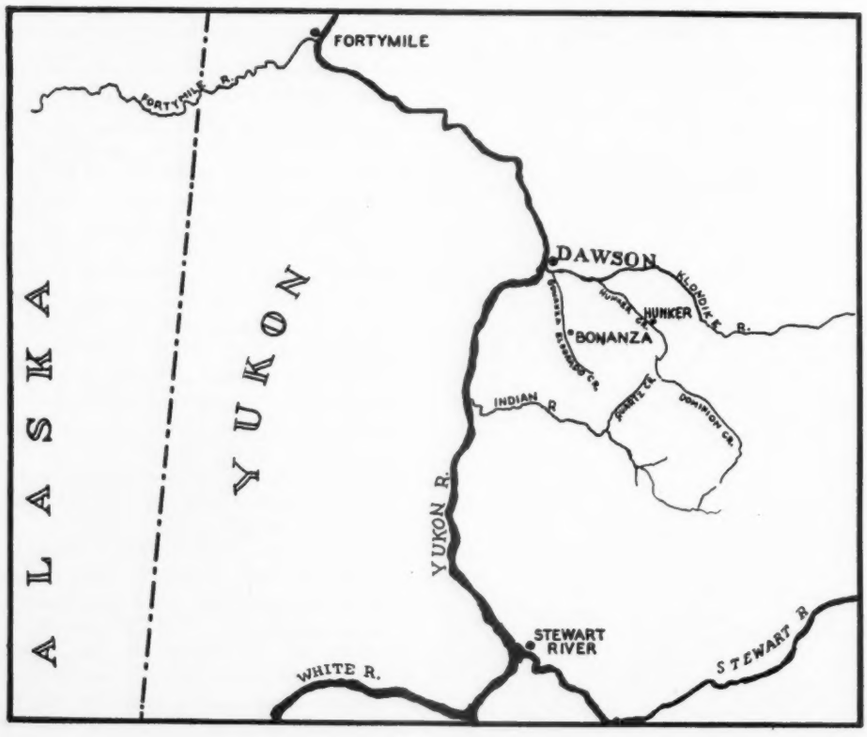
Events to the south, however, could not fail to have their effect upon the Yukon, because it was exactly the type of country to which gold seekers would turn their eyes, and a number of men wandered into the region. The exact date of earlier finds are somewhat difficult to determine; but it seems to be fairly well established that the first man to test out the possibilities of the country in an organized way was Arthur Harper who was born in County Antrim, Ireland, in 1835. Harper apparently was a born prospector. Like so many Irishmen, he left his homeland while still very young, and eventually drifted into the western gold fields of the United States. The discoveries in British Columbia during the sixties called him, and finally he wandered up to the Yukon. In 1872, in company with four others—an Irishman, an Englishman, a Canadian, and a German, he started a series of organized explorations which in time took him over a large part of the territory.

Without recounting in detail the prospecting expeditions of Harper, it is sufficient for present purposes to know that he and his close associate, Fred Hart, carried out some remarkable journeys. They set out from the upper Peace River in British Columbia, reaching the great Mackenzie and following it down to the Peel, which drains the country between the Mackenzie and the Yukon. From the Peel they crossed the divide to the Porcupine, down which they traveled to the Yukon River. Harper eventually summed up the results of his trip as follows: "On the Peace everywhere colours were found more or less, on the Laird colours, on the Mackenzie nothing, on the Peel fair prospects, on the Porcupine some colours, and on the Yukon prospects everywhere." Thus, in the early seventies, more than twenty years before the discovery of the Klondike, Harper made a summary of the region that proved to be entirely correct. He, personally, however, was never able actually to capitalize on the knowledge he had gathered, for in the end circumstances forced the man who had started out to establish mining in the Yukon into other lines of endeavor. He lived in the country 24 years and died in 1898.

In 1883 a party worked over the Dyea Pass to the headwaters of the Lewes River —really the headwaters of the Yukon— and followed the water route down to the Stewart River, a few miles upstream from the Klondike, where they found gold. So far as can be determined, not much work was done until 1885; and the first recorded output of gold in the territory was in the years 1885-1886. It amounted to about $100,000; and there was considerable activity in 1886.

In that year two men, one named Franklin and the other Madison, struck coarse gold in the Fortymile River area, which is some miles down the Yukon below Dawson. Those discoveries completely eclipsed the Stewart diggings, which were practically deserted in 1887. As the Fortymile discoveries lay in American territory, the gold production of the Yukon dwindled away to a mere trickle. The Fortymile district held the stage for some years and was succeeded by Birch Creek, which became a highly prosperous area. Thus, in viewing the situation in 1885, we find Alaska dominating the scene with a gold output of about $400,000 and the Yukon trailing with around $250,000.

Then came the Klondike, which sent the world into a dither of excitement and created a gold rush that has been the subject of more tall stories and lurid verse than possibly any gold stampede in history. The Klondike takes its name from the river basin in which the gold-bearing gravels occur. The stream which is now known as the Klondike was originally called "Tron-Deg" by Arthur Harper, to whom we have already referred. So far as can be determined, Harper anglicized the



THE AREA AROUND DAWSON

Gold was reported in the section north of Dawson in the seventies, but no mining was done then. In 1883 there was placer activity along the Stewart River, and by 1885 there was a number of settlements along Fortymile Creek. The richer discoveries around Dawson were not made for another decade. Production reached a peak of $22,000,000 in 1900, and then steadily declined. The streams shown are those that yielded the richest harvest of gold.

Ewing Galloway Photo

ALONG THE TRAIL OF NINETY-SIX

The Village of Lake Atlin, north of Juneau, Alaska, and some of the mountains that were crossed by those who joined the gold rush to the Klondike. The greatest barrier was Chilkoot Pass, where many perished in the snow and cold. Some of their experiences were reënacted in the motion picture, "The Gold Rush," which was made by Charles Chaplin a few years ago. The journey to the Klondike area is now a comparatively easy one.

original Indian name of "tron-duick" or "tuick"—which means hammer-water—into "Tron-Deg," and then a gradual evolution in euphony converted it to Klondike, by which name it became famous.

The first man to find gold in the Klondike was Robert Henderson, a Nova Scotia sailorman who took to gold-hunting as sailors so often have. In 1894 Henderson with two partners, Kendrick and Snider, ascended Indian River, which lies parallel to the Klondike, the two streams being only 15 miles apart. The party wandered up a tributary waterway which they named Quartz Creek. For two years or so Henderson worked on that creek with very indifferent results; and he was alone most of the time because his partners gave up the venture early in the game. During his solitary life he met with a serious accident to his leg which might easily have killed him and left his fate forever unknown. As it was, it laid him up for sixteen days. At this late date, with all the early color and glamour of the Klondike fading in the minds of men, we can spare a thought to what an endless length of time that must have seemed to that lonely, helpless man who lay in pain, and possibly delirium, with the wilderness pressing in on him. However, his iron constitution and his will to live carried him through, because at the end of the sixteen days he dragged himself to a boat of skins he had constructed and floated down the Indian River.

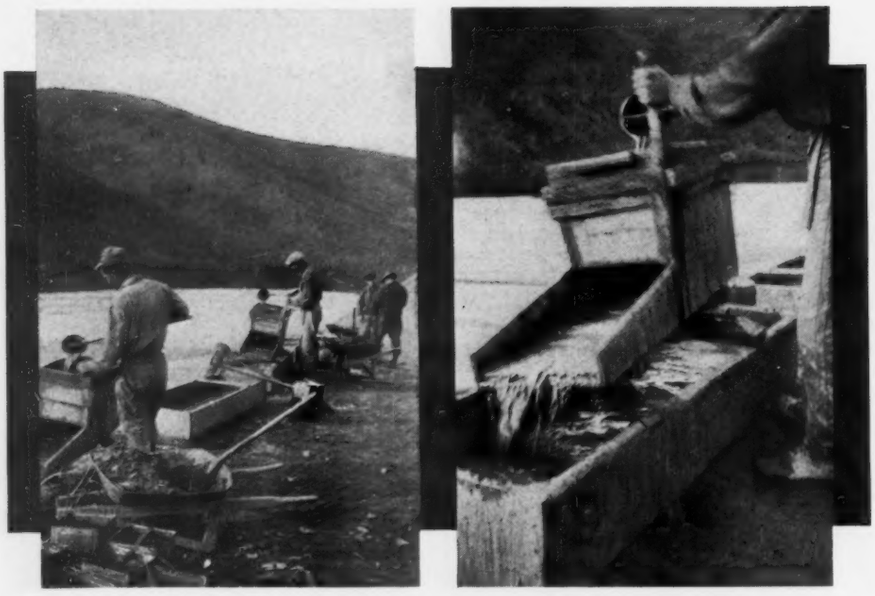
The next year he was back, and crossed the divide at the head of Quartz Creek. This brought him to the Klondike River side, where he followed a stream which he called Gold Bottom Creek and where he obtained some rather good values. He made up his mind to locate there, and in July of 1896 he worked down Gold Bottom Creek to the Klondike River, continuing thence downstream to its junction with the Yukon. Here he met no less a person than George Washington Carmac, who has often been described as the discoverer of the Klondike and who did, as a matter of fact, find the famous Bonanza Creek. Carmac, who seems to have been an Irishman, was a close associate of the natives, and when Henderson met him was engaged in salmon fishing with two Indians, Skookum (strong) Jim, and Tagish Charlie.

Henderson told Carmac of the new discovery and strongly urged him to get in on it. Carmac promised to do so; but apparently some coolness sprang up between them owing to the Indians, regarding whom Henderson seemed to have very decided ideas. Anyhow, Carmac did not hurry to get to Henderson's location; and some twenty days later he ordered his Indian friends to get ready to take the trail. They traveled up the stream which was afterwards to become Bonanza Creek. While resting one evening they started to pan the gravel "for fun." The term is Skookum Jim's when recounting the event in later years. They obtained very high values, and made up their minds to return if results at Gold Bottom Creek were not so good. This was a natural-enough decision, but it developed some shortcomings in the light of later happenings.

The party followed the Bonanza to its junction with the creek now known as Eldorado. Here they took the divide between the two waterways until they reached Henderson on the Gold Bottom. They stayed with him a day or two and then, finding that the values there were lower than those they had discovered, they left without mentioning their own find. This, of course, was contrary to the unwritten code of placer miners. Subsequently they excused their omission on the strength of Henderson's inhospitable attitude. In any case, Carmac and his associates returned to the scene of their strike, and on the morning of August 17, 1896, made the first recorded stakings in the Klondike. Carmac staked the discovery claim on Bonanza

YUKON MINING TODAY

DESPITE its drop in production, the Yukon is still Canada's leading source of placer gold, and geologists foresee continued yields for 50 years to come. In the Klondike area alone there are sufficient gravels to keep the dredges busy for fifteen years. Placer production in 1937 was $2,042,000, and the all-time output is now nearly $200,000,000. Yukon Consolidated Gold Corporation holds virtually all the known placer reserves.



YUKON HANDROCKERS

Although most gold is now recovered from the Yukon gravels by mechanical means, considerable hand mining persists. At the left are shown handrockers in use along the edge of a stream, and at the right is a closer view of this type of apparatus. Gravel is shoveled into the box on top which contains a coarse screen or perforated plate. Water poured over the gravel carries the smaller material through to the sloping bed, where riffles and usually a piece of Brussels carpet capture the gold. Worthless material, being lighter, is washed away. To facilitate the process, the entire assembly is mounted on rockers, permitting it to be tilted back and forth by means of an upright handle.

Creek, together with No. 1 below it. No. 1 above was staked for Skookum Jim, and No. 2 below for Tagish Charlie.

In a few days the rush was on, and Bonanza and Eldorado creeks were staked solid for miles. Henderson, who was working hard on his location, did not even hear about the startling news for some time, and then one of those peculiar twists of Fate which seem so much a part of mining dealt rather unkindly with him. Henderson hated to lose the fleeting summer days in recording his claim. In his decent, quiet way he left that little matter until the winter, knowing full well that the unwritten law of the miners would protect him from any claim-jumping. In his own mind, Gold Bottom Creek was so peculiarly his that he never entertained a thought that anything could happen to his tangible and intangible claims to it. He had found it in the first place after long journeys and disappointments; he had worked on it, starved on it, and proclaimed it. He had invited all and sundry to participate; and there is no doubt that the second group of stakings on Bonanza Creek on August 19, 1896, just two days later than Carmac's, were made by men who were looking for Henderson in order that they might tie on to his discovery.

During all this excitement there came up the Klondike one named Andrew Hunker. In the inevitable course of things he explored many tributary streams. At last, selecting one, he ascended it a few miles, panning here and there, and finally struck excellent values. He staked, and then turned back to the recording office where he not only recorded the discovery claim but named the waterway Hunker Creek after himself. His claims were allowed; and not until Henderson attempted to record his own discovery was it found that Hunker Creek was in reality Gold Bottom Creek. Thus the man who had labored so long, and had so freely shared the fruits of his search, was left with nothing but a very ordinary claim.

There is no doubt that Hunker acted in good faith. The country is full of streams; and he was not aware that he was on a creek already discovered and tentatively named. It is true that Henderson had placed a crudely written sign at the junction of the creek and the river, informing the world in general that "This creek is to be known as Gold Bottom Creek"; but Hunker said he missed it. There is not the slightest reason to disbelieve him, for the miners of that day (and at that time they were real miners in and about the Klondike Valley, the scum came later) were a tough lot with very definite ideas about equity and justice. So much of their lives had been spent in far-flung districts, where organized law and authority was a very shadowy force, that they had developed a sort of common law or code unto themselves which was based on the rights of prior discovery. Had there been any question in the minds of those rough men regarding Hunker's good faith, it is more than likely that they would have turned him out of the district in a hurry in spite of any rulings of the recording office, because Henderson was widely known and well liked. Hunker Creek subsequently became one of the Klondike's famous gold-bearing streams.

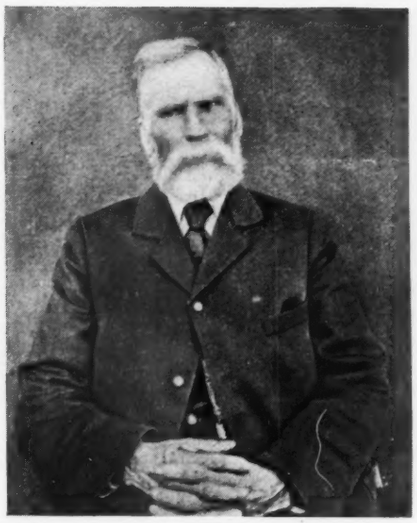
From this point on the Klondike developed rapidly. In 1896 it produced about $300,000 worth of gold. In 1897 the output jumped to $2,500,000, and to $10,000,000 in 1898. By 1900 it reached its peak, with a production of well over 1,000,000 ounces valued at $22,275,000, and a high value was maintained for several years thereafter. This great stream of wealth found its way into the credit reservoirs of the world through many questionable hands, because Dawson, lying at the junction of the Klondike and Yukon rivers, became the center of the gold fields and a place of strange and varied activities. It naturally attracted hordes of people that catered to the diversified needs of the miners.

It became a town of strange values and strenuous amusements. Gold was the medium of exchange, and there was not a store, a dance hall, bar, gambling saloon, or hotel that did not have its pair of scales for weighing gold. It can easily be imagined that the prices of commodities and of amusements soared to fantastic heights. It was a tough town, a very tough town, and there was some viciousness; but not too much thanks to the famous North West Mounted Police—now the Royal Canadian Mounted Police—who maintained law and order in a way that is still spoken of admiringly.

Previous to the Klondike rush, Circle City, lying in United States territory, had been the metropolis of the Yukon River Valley. It also was a tough place in which a primitive form of racketeering, terrorism, was carried on by organized gangs. When Dawson sprang into prominence almost

A YUKON DREDGE

An endless chain of buckets scoops up gravel and delivers it to a mechanical gold-washing plant, where the precious metal is extracted. The tailings are run out behind by a belt conveyor.



ARTHUR HARPER

The first man to look for gold in an organized way in the Yukon. With Fred Hart, he made a trip in 1872 down the Peace and Mackenzie rivers, and thence across to the Yukon River watershed. They found placer gold in many places; but did not return to them to attempt to capitalize on their discoveries.

overnight, these various gentry decided to transfer their predatory operations to the more prosperous town. They therefore moved over full of hope and questionable ambition; but they promptly found that they had to contend with certain long-limbed, highly efficient officers of Canadian law who were used to dealing with extraordinary situations in places far removed from the ordinary amenities of civilization. At first they could hardly believe their senses when informed that their activities were undesirable; but they soon learned that the incredible had happened—law and order had come to the Yukon, and it stayed.

The administration of the Klondike by the North West Mounted Police is a splendid record. They dispensed law with tolerance and wisdom. They realized the fact that in such a primitive region, peopled with hordes of men many of whom were making money at a great rate, their administration could only be based on the acceptance of certain fundamentals such as wine, women, and song. While the police did not always act in accordance with the strict letter of British law, they had a way of interpreting it to suit the particular situation involved, and they did a magnificent job in the Klondike. So long as those engaged in serving the mining community with the essentials and non-essentials of life conducted their affairs without viciousness, the Mounted Police kept an eye on them only; but the moment they overstepped the mark, the long arm of justice reached out in no uncertain way. There is no doubt that the great body of real miners in the area supported the Mounted Police in their maintenance of order; and while Dawson was a "wide-open" town and simply appalled many people with the variety and garishness of its sinfulness, it was singularly free from any strong undercurrent of lawlessness and viciousness.

Dawson or Dawson City, as it is also called, is named in honor of Dr. G. M. Dawson, who was considered one of the world's leading geologists and was successively assistant director and director of the Geological Survey of Canada. It was Doctor Dawson who, together with other members of the Survey, conducted the field work in the seventies and eighties which formed the basis for the maps and reports which to this day are the most authoritative sources of information on the geology of the Northwest Territories, British Columbia, and the Yukon.

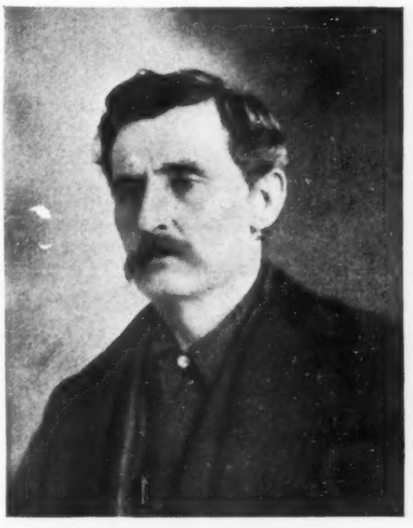
Meanwhile the Klondike had attained a place in the imagination of the outside world that was nothing short of fabulous. The popular conception of it seemed to be that it was a region in which every stream bed was carpeted with large nuggets of gold, and that one had but to reach it to become wealthy beyond the wildest dreams. As a result, clerks dropped their pens in the cities of the world, and men left a multitude of occupations as far separated from the actualities of placer mining as the sun is from the earth. They came in swarms—some inspired by the spirit of adventure and high romance, others by avarice. Some came up the great Yukon River from the sea, but most of them came overland through the mountain passes at the coast and down the river. How many left their bones by the way will never be known. In the first frantic rush there was little organization; and many men were utterly unfitted for the journey both in resources and outfit. Later the Mounted Police supervised the inward movement, and certain definite requirements as to resources were formulated. Those that were not equipped for the journey were turned back; but all manner of men participated in the early rush, and the ruthless weeding out of Nature eventually governed the numbers that finally reached the fabled gold fields of the Klondike.

As the years went on, the output of the Yukon slowly dwindled. As the richest gravels were worked out more modern methods came into use, until today substantially all the gold originating from the gravels of the Yukon is won by mechanical means. Men still employ rockers, just as they do in British Columbia, but their contribution to the total production is comparatively small. Huge dredges have taken their place. These scoop the gravel up in tons at a bucketful, extracting from each its mite of gold before discarding it in tailing piles.

Since 1885 the Yukon has yielded about $200,000,000 worth of gold at its statutory price. Nearly all this has been obtained since 1896 and shows, far more than descriptive words ever could, the richness of the gravels of the area. It is true that the glory of the Klondike has passed, and that the splendor of its heyday is fast becoming a fading memory in the minds of men who are growing old; but it is still a highly productive district and undoubtedly will continue to be one for years to come.

Thus we come to the end of this fragmentary history of placer mining in the Province of British Columbia and Yukon Territory—a history that has carried us back more than 80 years and that has permitted us to touch only certain highlights. Below these lies a wealth of forgotten effort; and could we but look closely, we would see a long line of shadowy figures whose names have passed from the ken of men today. Each and every one of them contributed something to the ultimate sum of accomplishment that has been witnessed by the years; but we can never record their individual contributions, for, in the end, histories, like biographies, consist of a few high spots amid a succession of drab days and quiet events. But before passing on to the other great phase of western mining, we should pay the tribute of remembrance to the army of unknown men who wandered through the mountains and along the streams of British Columbia and the Yukon and gave to us a great heritage. We should salute the dreams which drove them on, for though those dreams pitifully enough often "Flickered but in yellow flame behind a dawn that never came," they nevertheless gave us knowledge to profit by and a prosperous mining industry.

This is the third of a series of articles by Mr. Rowe. The fourth will appear in February.



ROBERT HENDERSON

Generally recognized as the discoverer of the Klondike placers, Henderson missed riches by failing to record his claims promptly. While he was busy on what he had called Gold Bottom Creek, another prospector, Andrew Hunker, came upon a stream that revealed gold-bearing gravels and forthwith filed on it under the name of Hunker Creek. Subsequently, when Henderson attempted to record his claims, it was discovered that Gold Bottom Creek and Hunker Creek were one and the same stream.

Chicago Starts Building a Subway

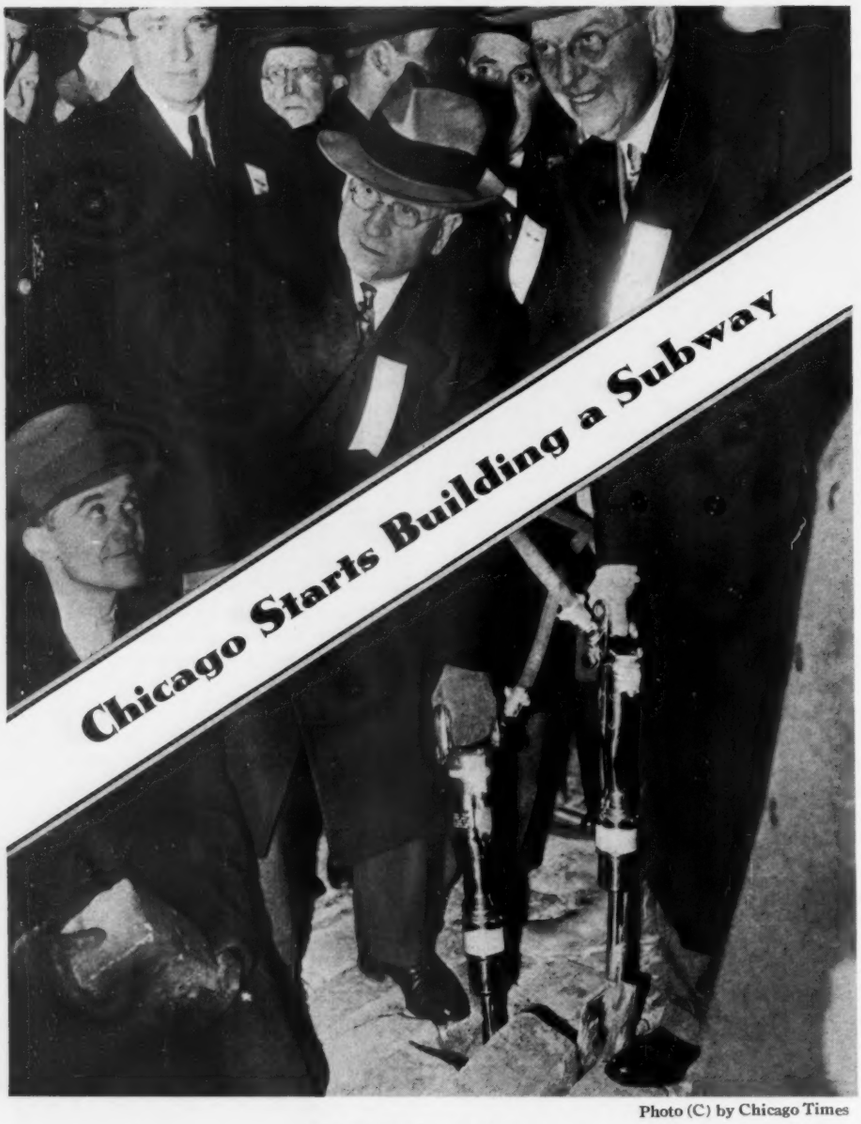


Photo (C) by Chicago Times

BREAKING GROUND

Harold L. Ickes (left), Secretary of the Interior and PWA Administrator, and Mayor Edward J. Kelly of Chicago, breaking ground on December 17 for the first section of Chicago's long-needed subway. They are using Ingersoll-Rand Size 73 clay diggers. Approximately 10,000 persons attended the ceremonies, which marked the termination of a 30-year campaign for relief of the city's transit congestion.

USING up-to-date pneumatically operated tools, Mayor Edward J. Kelly of Chicago and Secretary of the Interior Harold L. Ickes formally broke ground on December 17 for Chicago's first subway construction. While 10,000 persons watched, they loosened a few paving blocks on State Street, near Chicago Avenue, and thereby signalized the start of a $40,000,000 program which will provide the city with 7½ miles of underground rapid-transit railway.

The beginning of actual work is the culmination of more than 30 years of planning, during which period the city's famed Loop elevated railroad has become more and more inadequate for the steadily mounting traffic in and near the business section. Many times previously it seemed as though subway construction was about to be undertaken, but on each occasion difficulties of a political or a financial nature arose to prevent it.

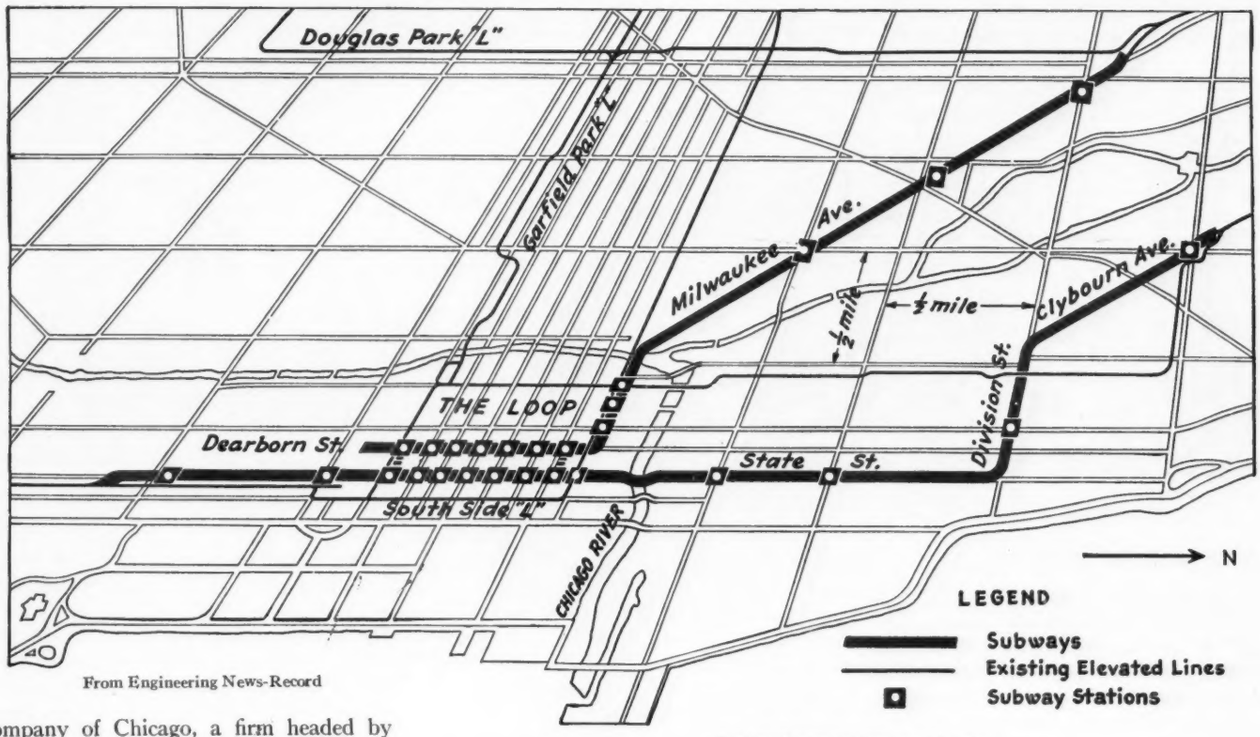
Chicago began talking about a subway in the eighties, but it was not until 1909 that the first definite proposal was made. In that year City Engineer John Ericson submitted a plan for an underground railway in the Loop area. Thereafter, different schemes were proposed, discussed, and some of them voted on in 1912, 1913, 1916, 1925, and 1930. In each instance, however, obstacles of one sort or another blocked actual construction, and it was not until there was a possibility of obtaining Federal assistance that a workable plan was developed.

The current program is the outgrowth of plans submitted by Chicago to the Public Works Administration of the National Government. These plans were prepared by Philip Harrington, traction engineer for the city, and Charles E. DeLeuw, consulting engineer. They called for the expenditure of $32,000,000. In his capacity of PWA Administrator, Mr. Ickes, who as a resident of Chicago has long been interested in its traction problems, received the plans. He appointed a board of consulting engineers to study them and to make recommendations. The board was headed by H. M. Waite, former deputy PWA administrator. Other members were the late Robert Ridgway, builder of New York subways; H. M. Brinckerhoff, New York consulting engineer; and Joshua D'Esposito, PWA resident engineer in charge of the $80,000,000 construction program being carried out by the Sanitary District of Chicago.

The board amplified the plans, proposing a greater mileage, major changes in some of the terminals, and tunnels instead of open cuts. This enlarged program, estimated to cost $39,910,000, was presented in a report along with the original scheme, which involved an expenditure of some $8,000,000 less. The broader plan was adopted, and on the basis of its specifications, the City of Chicago last October was given a PWA grant of $18,000,000, representing 45 per cent of the construction cost. The grant is contingent upon a promise of the city to pass a unification ordinance covering all surface and elevated railways and bus lines. Under the terms of the ordinance, a unified transit company will be required to pay a certain percentage of its gross receipts to the city. This fund will be placed in trust to be used exclusively for the extension of the subway until a comprehensive system has been completed. Thereafter the proceeds will go towards extensions, improvements, and general rehabilitation of the whole transit system.

The initial project includes two lines, both extending from the congested Loop District in a generally northward direction and connecting with existing elevated lines. In downtown Chicago one line will run under State Street, the city's principal shopping thoroughfare, and the other under Dearborn Street, one block to the west. In the Loop area continuous stations will be provided, and those on the two lines will be connected by underground passages for pedestrians.

In order to put the lines in operation as quickly as possible, the two routes have been divided into short sections for letting contracts. Bid openings are scheduled at 3-week intervals until all sections have been awarded, and it is expected that work on the final link will be started by next July. Each contractor will be required to complete all work within eighteen months. Meanwhile the letting of contracts for station construction will begin, with the last one scheduled to be disposed of by next August. The first contract, calling for the construction of a 3,600-foot section of tunnel and track structures, was awarded to the Herlihy Mid-Continent Construction



From Engineering News-Record

MAP OF FIRST ROUTES

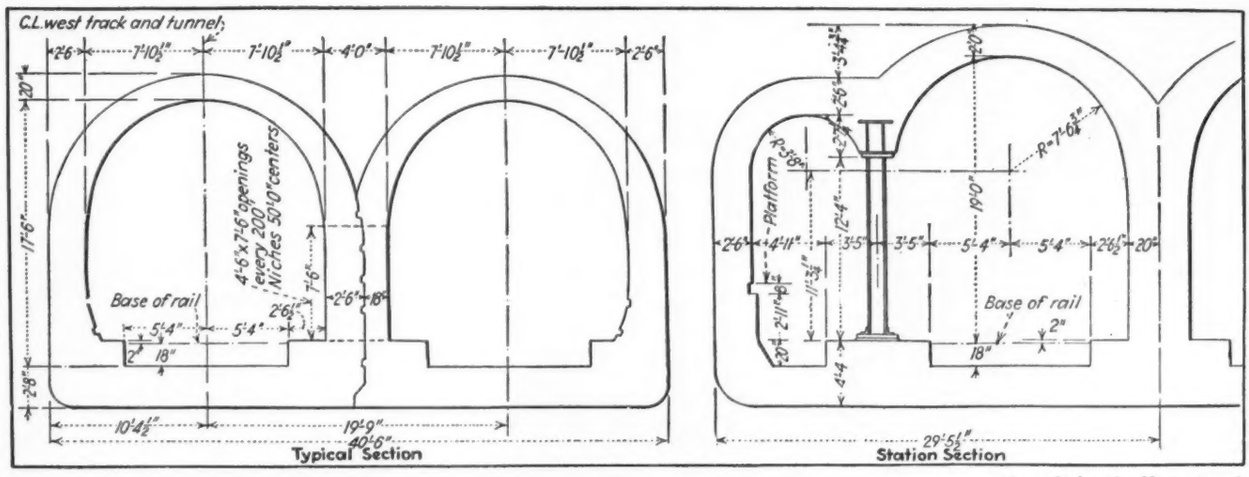
As shown here, the two initial lines that have been approved for construction will come close together in the Loop area, where practically continuous stations will be connected by transverse underground passageways for pedestrians. The Dearborn Street-Milwaukee Avenue line will begin at Congress Street and will connect at its opposite end with the Logan-Humboldt elevated line. The State Street-Clybourn Avenue link will connect with the Clybourn Avenue elevated line. Work was started on State Street, north of the Chicago River.

Company of Chicago, a firm headed by Frank J. Herlihy. This work will be done under State Street and between Illinois and Bellevue streets.

A typical section of the subway will consist of twin horseshoe-shaped tunnels with a monolithic concrete lining and a common center wall. The rails will be approximately 40 feet below street level. The subsoil is predominantly blue Chicago clay, and the tunnels will be driven under compressed air at a pressure of around 8 pounds per square inch. Station platforms will be built in smaller tunnels driven alongside the railroad tunnels. Cut-and-cover methods, as practised in New York, will be employed in the case of station mezzanine platforms, stairways, entrances, and connections. The openings will be 60x80 feet in area and from 18 to 20 feet deep.

Mr. D'Esposito has been named to represent the PWA as project engineer, and will continue to serve in the same capacity in connection with the Sanitary District improvements. Mr. Harrington, as Commissioner of Subways, will supervise the work for the city.

Speakers at the ground-breaking ceremonies hailed the work as the dawn of a new civic era in Chicago, which has for many years been the largest American city without a subway system. It is predicted that the program now being initiated will provide direct employment for from 5,000 to 6,000 men and indirect employment for 10,000 to 12,000.



From Engineering News-Record

SECTIONS THROUGH TUBES

General form and dimensions of the twin tubes which will be driven as tunnels under air at a pressure of about 8 pounds. The liner-plate, steel-rib, and needle-beam method of construction will be followed, and the concrete lining will be placed as excavating progresses. Station platforms will be built in smaller tunnels driven alongside the main bores. The base of the rails will be approximately 40 feet below street level. The subsoil is almost entirely blue clay.

ROBERT RIDGWAY

THE death of Robert Ridgway has removed an engineer who was perhaps connected intimately with a greater amount of construction work than any other man in history. For more than 50 years he filled varied engineering rôles for New York City, New York State, and for the nation. He played a bigger part in the designing and the building of New York's subways than any other person, his experience having covered the entire span of years from the beginning of the first line, in 1900, to the completion of the new Independent System. During that period hundreds of millions of dollars worth of work was carried out under his supervision or authorization. Meanwhile, he served as a consultant on subway construction in other cities, with the result that he was for many years considered the world's outstanding authority on underground railways.

From an obscure start as a rodman on railway survey work in Montana in the early eighties, he rose to the position of assistant engineer on the Croton Aqueduct water-supply system of New York City while still under 30 years of age. In 1900 he became senior engineer on New York's initial subway and continued in that capacity until 1904. In 1905 he transferred his activities and undertook to help New York obtain water from the Catskills. As departmental engineer, he had charge of driving a pressure tunnel in rock 1,100 feet beneath the river bed of the Hudson. In 1912 he returned to rapid-transit work, and in 1924 became chief engineer in charge of subway and elevated-railroad construction in New York City. During his long service in New York he found time to act as a consultant on such major projects as the Chicago subways, Boulder Dam, and the San Francisco Bay Bridge.

Upon being retired from public life in 1933, Mr. Ridgway, at 71, became a consulting engineer. His nature was such that he could not sit on the sidelines. He died in harness, having been stricken while aboard a train on which he was returning from Chicago, where he had participated in the breaking of ground for that city's new subway. His last work was to help shape the final plans for that undertaking.

Quiet, plain-living and plain-speaking, Mr. Ridgway was self-effacing in all that he did. He was not a college graduate, yet many colleges accorded him honors, and numerous engineering societies were proud to have him as a member.

CHANGES IN STEEL-MAKING

AMONG the important new rôles of the photoelectric cell is that of inanimate watchdog over open-hearth furnaces in steel-making plants. Its use for that purpose is a research accomplishment of the United States Steel Corporation.

Most common or carbon steel is made in the open-hearth furnace, and for many years the operator's eye has been the sole means of ascertaining whether or not the temperature was within the desired limits. This fallible method has become inadequate, it no longer meets the current requirements of close control of grain size and tensile strength—characteristics that are affected by only a slight variation in melting temperature.

In the words of steel technologists, the more positive and unfailing scientific means of temperature control will largely eliminate the necessity of holding steel-mill "autopsies." These are laboratory examinations of defective batches of steel to determine the cause of their inferiority. In most cases, the finding revolves around the subject of furnace heat. Additional benefits promised by the electric eye are a prolongation of service life up to 50 per cent of the refractory brick linings of furnaces, and a saving of time in the production of a batch of steel.

Last month we published a picture of a watchmaker in a steel plant. The extensive use of instruments in almost every department of steel-making has been one of the outstanding developments in the industry in recent years. Gradually the human element is giving way to the unerring precision of delicately adjusted mechanisms. As this era progresses, we are being carried farther and farther from the day of "ironmasters." Man's brain is still a dominant factor in steel-making; but the time has passed when his judgement alone is relied upon for the purpose of controlling vital processes.

GRADUATES AND JOBS

IN RECENT years, the average college graduate has, of necessity, taken whatever work he could get, laying aside any preference he may have had as to kind of employment or company affiliation. Naturally, many of them have found places with the large, established concerns, because such firms fortunately have had the reserve resources to carry on in difficult times and also to train additional personnel against future needs. In this respect they have been lighthouses in a storm, and both youth and industry owe much to them.

It is sometimes argued that a young man has a better opportunity of succeeding if he goes with a new, vigorous concern that has its major expansion ahead of it. This is a debatable question, to which only a Solomon can give the correct answer. Newly founded concerns may offer faster promotion; but when competition grows keen in their lines, then consolidation, efficiency surveys, and even bankruptcy often take a heavy toll among their employees. The bigger companies have survived many lean periods and grown wise thereby. They are conservative because they have learned that conservatism pays in the long run. Being impetuous, youth sometimes cannot understand this; but in reality that conservatism is protection—a form of insurance against the loss of their jobs in the future.

Industrial Notes

Approximately one-third of the total world production of glass, valued at $800,000,000 annually, is contributed by the United States.

According to recent statistics, approximately 33,000 horses are still used for underground haulage in British collieries. It is estimated that the cost of their feed is in the neighborhood of £1,170,000, or $5,475,000 in United States currency.

Gaskets of glass fiber woven to shape and size are the newest thing in the line of packings and are intended for use in equipment and pipe lines that handle acids. They are said to be soft, pliable, and resilient, and to resist the attack of all but hydrofluoric acid.

For separating iron from miscellaneous metal scrap that does not warrant the use of a powerful magnet, there is now available a small unit that has a maximum lifting capacity of 50 pounds. It has a handle on top with a trigger control switch, and is provided with an extension cord and plug. Direct- or alternating-current of not more than 220 volts is required for its operation.

Binks Manufacturing Company is offering a new gadget for use in connection with its paint-spray guns. It is a short attachment that is interposed between the inlet of the gun and the delivery end of the hose and serves to filter the paint as it passes through it. The screen inside the housing is of 250 mesh and can be removed for cleaning.

A filling-in job of an unusual kind is underway in Osaka, Japan, and affects about two-fifths of the city, or 16,500 acres. The elevation of this entire area is to be raised sufficiently to prevent it from being flooded as it has been frequently in the past. Approximately one-tenth of the land has already been filled in with earth to a depth of from 1 to 5 feet.

Something new in mudguards for large tank trucks designed for rugged service has been introduced by Leyland Motors, Ltd., a British manufacturer. They are made of heavy-gauge, diamond-shaped-mesh netting and are said to stand up far better than those of the familiar sheet metal to the heavy barrage of stones to which they are generally subjected on the rough roads for which the vehicles are designed. So that they will serve both as stone and mud catchers, the guards are provided with easily fitted rotproof canvas covers for wet-weather use.

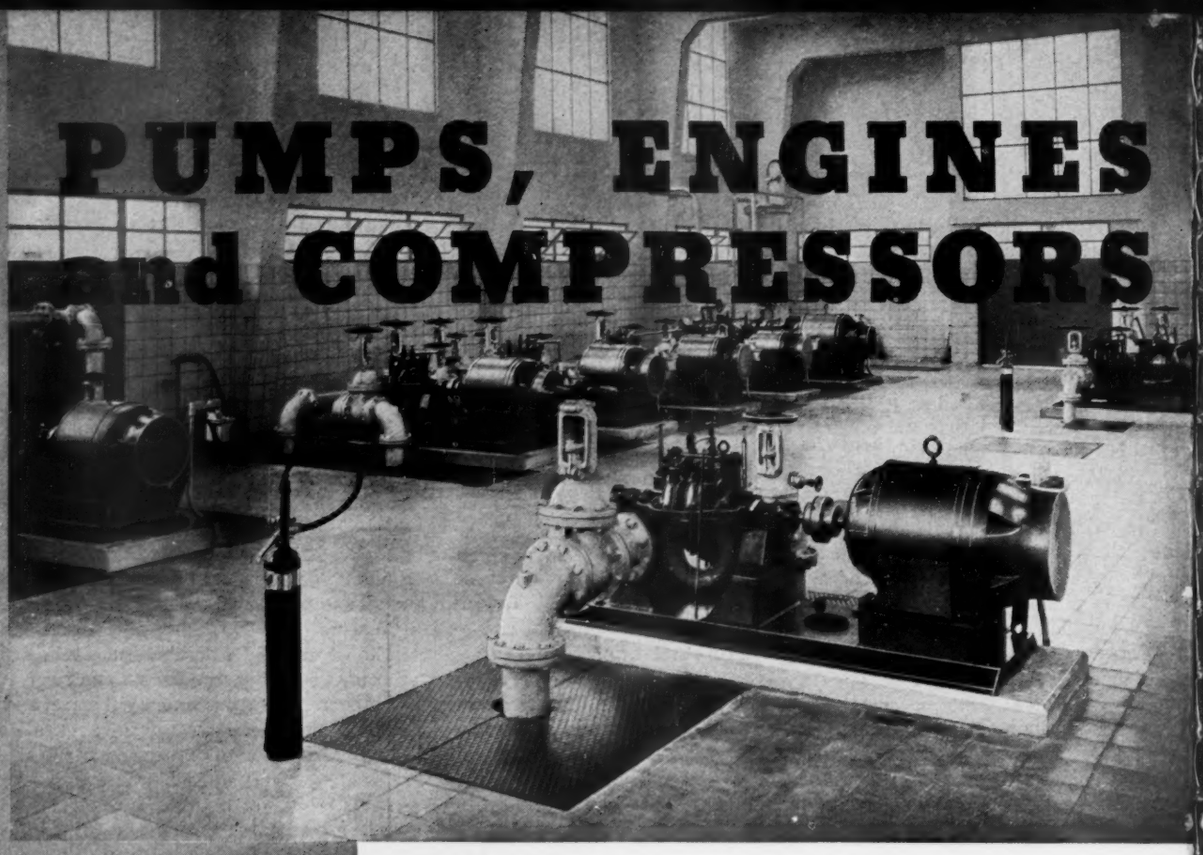
Under the heading of *Power Requirements in Electrochemical, Electrometallurgical, and Allied Industries*, the Federal Power Commission has recently published a 116-page report that should prove of considerable interest to engineers, economists, etc. It contains much valuable information in convenient form, and among its many illustrations are maps showing the locations of existing plants in relation to the sources of raw materials, markets, and present and potential power, as well as a diagram indicating the utilization of electric energy and the disposition of the products of the industries in question.

Courtesy of the London Times

THE LORD MAYOR'S SHOW

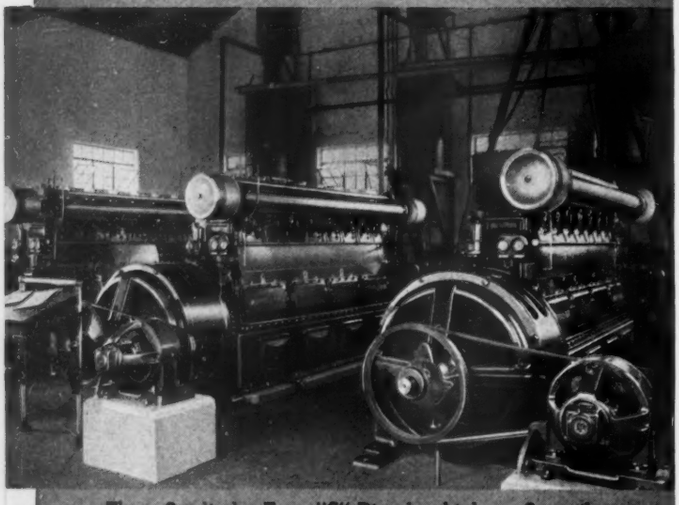
The Lord Mayor of London is elected by the aldermen on Michaelmas, September 29, of each year. He is sworn into office on November 8, and on the following day is presented to the Lord Chief Justice at the Courts of Royal Justice to take the final declaration of office. The pageant on that occasion is popularly known as the Lord Mayor's Show. The picture shows the Lord Mayor's coach, passing 165 Queen Victoria Street on last November 9. The new Lord Mayor is Sir Frank H. Bowater, who was elected to the Common Council of London in 1922 and who became an alderman in 1931.

PUMPS, ENGINES and COMPRESSORS

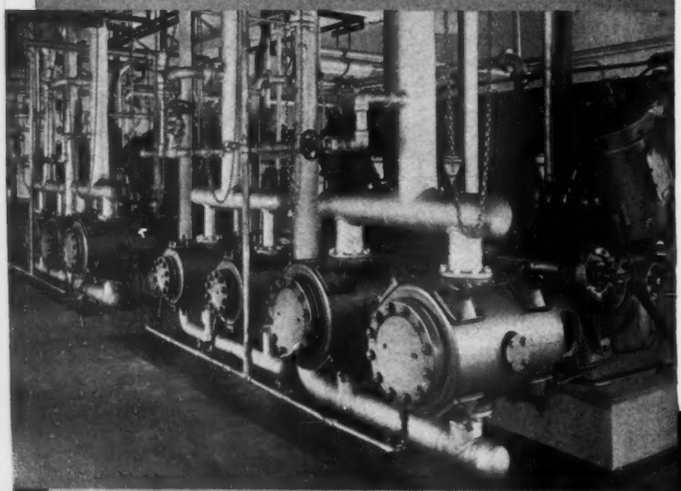


Cameron Refinery Pumps at the San Lorenzo Refinery.

All in One Refinery . . .



Three 8-cylinder Type "S" Diesels which ran 8 months without interruption at San Lorenzo.



Three 8-cylinder XVG gas-engine-driven compressor units installed in the San Lorenzo refinery.

Up-to-Date Equipment for the Modern San Lorenzo Refinery

(ARGENTINE GOVERNMENT OIL FIELDS)

Ingersoll-Rand is pleased to have had the privilege of furnishing the new San Lorenzo Refinery of the Argentine Government Oil Fields with so many different types of equipment. San Lorenzo is decidedly a well planned, efficient and modern refinery—a step ahead in refinery plant design.

It is indeed significant that three of the vital units selected by the officials were of Ingersoll-Rand make. These units, (illustrated here), are multi-stage pumps, gas-engine-driven compressors and Diesel engines. All have given excellent service. The Diesels operated eight months without a stop.

San Lorenzo is another example where I-R gave an "all-around" refinery service. Many refineries have found that this undivided responsibility assures them of more efficient and more reliable operation.

Other I-R products for the oil industry include impact wrenches, hoists, pneumatic tools, rock drills, portable compressors, etc.

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